ACTA PHYSIOLOGICA LATINO AMERICANA

VOLUMEN 4

Nº 3

1954

ACTA PHYSIOLOGICA LATINOAMERICANA

Editada por la Asociación Ciencia e Investigación

COMITES EDITORIALES

Esta revista se edita con la ayuda del Fondo Alejandro Menéndez Behety.

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Cada tomo (cuatro números trimestrales) $ 50.— m/n. Exterior: 5 dólares

REPRESENTANTES:

Brasil: Editora Guanabara, Waissmann-Koogan, Ltda.
Rua do Ouvidor, 132, Río de Janeiro.

EE. UU.: Stechert - Hafner Inc.
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Distribuidor:
BRANDT LABORATORIOS
Sarmiento 4130
Buenos Aires, Argentina

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Acta Physiologica Latinoamericana

Vol. IV - N° 3
1954

ASOCIACION CIENCIA E INVESTIGACION
Buenos Aires - Argentina

PRESSURE-VOLUME RELATIONSHIP IN THE PULMONARY VASCULAR BED

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IT HAS ALWAYS been claimed that the pulmonary vascular bed is very distensible, i.e. of large volumetric capacity. This concept was supported by several facts like the low pressure within the pulmonary vessels and the hardly noticeable changes when a large proportion of the pulmonary vascular bed is excised or when the cardiac output increases considerably (1, 2, 3, 4, 5, 6). Nevertheless there have been discrepancies (7, 8, 9, 10). Therefore we thought it of interest to determine the coefficient of volumetric elasticity of the pulmonary vascular bed under several experimental conditions.

METHODS

The pressure-volume relationship was studied in 24 dogs, 15 to 25 kg weight, anesthetized with chloral-morphine and under artificial respiration. The main left pulmonary artery and the three veins were isolated through a left antero-lateral thoracotomy. At a given time, a simultaneous occlusion of the artery and the veins was performed. The left pulmonary artery was then cannulated and connected with a three way stopcock, permitting alternative recording of pressure with a Hamilton manometer and injection of fluids through the same cannula. Heparinized blood was used primarily; occasionally citrated or defibrinated blood was used. The blood was filtered when there was a question of the presence of clots. One to three cc of blood were injected each time; the blood pressure was recorded immediately thereafter. In four cases an embolization of the arterio-capillary bed was performed by injecting a 20% suspension of potato starch and recording thereafter the pressure in the same vascular bed, beginning with pressures of 0 mm Hg and injecting 0.20 to 1 cc of blood each time. In one experiment, the

Received for publication July 6th, 1954.

injections were made through one of the pulmonary veins while a continuous record of pressure was made in the arterial side. In another experiment, the pressure was recorded in the venous side with a water manometer while the blood was injected into the artery. In six dogs an isotonic saline solution was used for these injections. The temperature of the blood and saline solutions fluctuated between 18 and 22 degrees C.

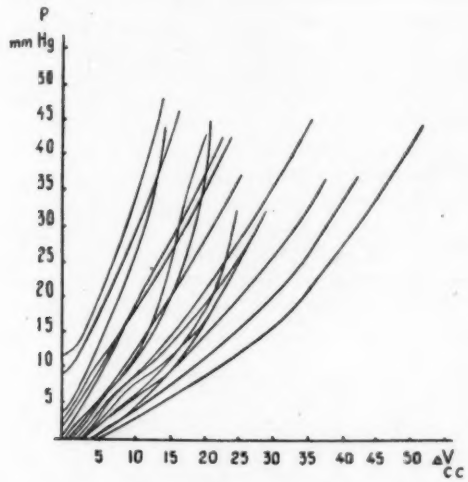

FIG. 1.—*Pressure-volume curves (standardized)*

Occasionally, although the cannula was introduced in the main left branch with the intention of including the whole left lung, the tip of the cannula was advanced within the lower lobe branch and the curves obtained therefore were representative only of the characteristics of that particular lobe and not of the whole lung. In two animals the chest was closed after inserting the cannula, the pressure-volume curve was then studied keeping a subatmospheric pleural pressure by means of a continuous suction.

RESULTS

The recorded pressures showed that after each injection of blood there was an increase in pressure in a linear relationship; each cc evoked a pressure rise of 1 to 5 mm Hg (fig. 1). The initial pressure varied between O and 12 mm Hg. This was dependent, probably, upon the phase of the cardiac cycle in which occlusion was performed or whether or not the artery was ligated slightly before the veins as did happen on a few occasions. The curves were followed up to pressures of 35 to 47

mm Hg. In those cases in which only one lobe was involved because the tip of the cannula had slipped into a secondary pulmonary branch, a 1 cc increase in volume induced a pressure increment of 5 mm Hg.

Since a) the curve recorded when the blood was injected through the pulmonary vein was identical with the curves observed under the arterial injection, b) the injection through artery caused an immediate increase in pressure on the venous side, and, c) when a venous ligature was loosened the pressure in the arterial side dropped rapidly to zero, we believe that these curves are representative of what happens in the pulmonary vascular bed as a whole and not only in a part of the vascular bed. In the two experiments performed with the closed chest the results were the same as those seen with open chest.

When an embolization was previously performed, the injection of 0.20 to 1 cc of blood evoked a pressure rise of 35 to 42 mm Hg and loosening of the venous ligatures would not cause the usual fall in pressure. This would mean that in these cases the curve shows only a characteristic of the arterial segment of the vascular bed.

In several cases the pressures were recorded not only after the injections but also after graduated extractions which enabled us to obtain an extraction curve. It was observed that extracting a certain amount of blood will give a greater fall in pressure than the rise obtained by injecting the same amount.

Discussion

The pressure-volume curves of the pulmonary vascular bed show that small increments of volume induced striking pressure rises. This would mean that this particular vascular bed has a high volumetric elasticity coefficient. This behaviour, apparently passive, of the pulmonary vessels has been suggested by Oschner (8) and by Sarnoff and Berglund (11), who in experiments very similar to our own obtained almost identical results. It is of interest that Hellems et al. (12) in their study of "capillary" pressure in dogs, observed in one animal with a catheter in an arterial branch and one in a venous branch of the same lung lobe that the injection of 1 cc of saline solution through either one caused an equal pressure rise of 50 mm Hg on both sides.

Like Sarnoff and Berglund (11) we also observed that the extraction curve is lower than the injection curve. These authors thought that this meant a loss of fluids through the capillaries and or a change in the distensibility of the vascular bed. We think that this phenomenon might be caused by the fact that the extraction curve shows more specifically what happens in the arterial segment since the suction with the syringe could collapse the capillaries or the arterioles and thus hinder the backflow of blood from the veins.

With regard to the steep augmentation in pressure with small volumes of injected blood obtained in the embolized lung, we believe this is a sheer demonstration of the rigidity of the arteries. This characteristic would explain why during systole the pulmonary arterial pressure in men rises from 10 to 25 mm Hg with a stroke volume of about 60 cc

for the two lungs even with an open drainage to the capillaries, veins and left auricle.

The slight distensibility of the pulmonary vascular bed in these experiments poses a very difficult problem. On the one hand observations by Hamilton and Cargill (1), Riley et al. (2), Cournand (3) and even those by Dexter et al. (4) seem to support the idea of great distensibility of the pulmonary vascular bed; on the other hand, curves obtained by Sarnoff and Berglund (11) and ourselves seem to show the opposite. Thinking that a theoretical approach could throw some light on this problem we might recall that in Poisseuille's Law the difference of pressure between two points of a fluid stream is directly proportional to the flow and inversely proportional to the fourth power of the radius. Since the other factors, length, and coefficient of viscosity would remain constant in the present situation we could formulate: $Pa\text{-}Pb = \frac{F}{r^4} \times K$. In this formula Pa is the mean pressure in the pulmonary artery, Pb is the mean pressure in the left auricle, F is flow in cc per minute, r is the radius and K a constant involving length and coefficient of blood viscosity. From this formula we would have to accept that in increasing F three times, the fourth power of the radius would have to show a three fold rise as well, if the pressure gradient is to be constant. If $F' = 3 \times F$, then $r'^4 = 3 \times r^4$. This would mean that

$$\frac{r'^4}{r^4} = 3. \text{ Then } \sqrt[4]{\frac{R'^4}{R^4}} = \sqrt[4]{3} \quad \text{and} \quad \frac{r'}{r} = \sqrt{\sqrt{3}} = \sqrt{1.72} = 1.32$$

$$r' = r \times 1.32$$

Thus if the pressure is going to be constant a threefold increase in flow requires that the radius of the vascular bed increases 32 % and thence the volume of this particular bed would have a 70% increase.

If we admit that the total pulmonary blood volume is about 1 000 cc (14, 15), an increase of volume of this magnitude would imply a huge amount of blood (700 cc) collected in the lungs, and this would undoubtedly affect the respiratory function and contradict the findings by Doyle et al. (16) showing the relative constancy of the pulmonary blood volume with different cardiac outputs. On the other hand, if we accept Roughton's (17) figures of 60 cc of capillary blood and an increase to 90 cc during exercise, this would not mean a collection of blood significant enough to interfere with the pulmonary function. However, these last findings result from indirect methods and disagree with most other investigations. Therefore, accepting a pulmonary blood volume of about 1 000 cc, the former theoretical considerations and our findings seem to indicate that the pulmonary vascular bed is distensible only in a minor degree. An explanation for the relative constancy of the pulmonary pressure and pulmonary blood volume with a variable cardiac output is still pending. We believe that this could be explained by accepting the

idea that the main resistance to flow in the pulmonary vascular bed is located in a short segment of it, probably in the small muscular arteries, and this would be the only segment to dilate to 30%. The distension of only a short segment would, therefore, explain the lack of significant increases of the pulmonary blood volume and at the same time the fall in peripheral resistance, resulting in an almost constant pulmonary arterial pressure despite increments of cardiac output.

SUMMARY

The pressure-volume curve is studied in 24 dogs with open and closed thorax. The increase of pressure produced by gradual increase of blood volume in the vascular bed of the left lung excluded from the circulation by clamping the main pulmonary artery branch and the three pulmonary veins of that side was measured. The results show that the distensibility of the vascular bed is small since the increase in volume of only one cc shows an increase of 1 to 5 mm Hg.

These findings are discussed in relation to the knowledge that the pulmonary arterial pressure does not rise until the cardiac output is markedly increased.

ACKNOWLEDGEMENTS

We acknowledge the technical assistance of Mr. P. M. García, Mr. F. de Martino and Mrs. L. O. M. de Caraglio.

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THE INFLUENCE OF TEMPERATURE UPON THE RESPIRATORY METABOLISM OF CERTAIN TROPICAL AQUATIC INSECTS

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THE METABOLIC response of poikilometabolic animals to fluctuations in environmental temperature can be expressed in three ways: (a) by a single metabolism-temperature (M-T) curve, (b) by a curve whose slope remains constant, but whose position shifts with season or latitude, and (c) by a curve whose slope shifts with season or latitude, i.e., a shift in temperature coefficient (Q_{10}). The single M - T curve typifies the response of all insects reported to date (6). A seasonal, or latitudinal, adaptation to temperature change, i.e., the second type of M - T curve, has been demonstrated in the sand crab (7) and in certain other crustaceans, fishes and molluscs from arctic and tropic waters (23)). A shift in Q_{10} has been predicated for two arctic fishes (18), although it is difficult to understand how this can be regarded as an adaptation to cold; this type of adjustment being actually more suitable to desert forms.

All terrestrial invertebrates, including the insects, exhibit the single M - T curve. This is rather amazing when one considers the abundance and diversity of ambients occupied by the insects. Even such insects as *Thermobia*, with a temperature preference of 39-43°C, and *Grylloblatta*, with a temperature preference of 3°C, have the same M - T curve. *Thermobia* extends the curve upwards and *Grylloblatta* extends the curve downwards, thus giving different death points for the two insects, but the slope of the curve remains the same for both (9). Evidences of possible metabolic adjustment to offset temperature changes are found in solitary bees (17) and in the colonial responses of the honeybee (29). Arctic and tropic insects show similar M - T curves, but it can be noted that the arctic forms maintain a very slightly higher oxygen consumption at temperatures of 10 and 20°C (23).

In spite of the immense literature concerning the relations of

Received for publication July 10th 1954.

insects to temperature, there still remain two large gaps in our knowledge of their metabolic response. Information is lacking concerning insects from restricted environments, e.g. the Mallophaga, which live at the temperature of the avian host, as is lacking also information about aquatic insects from any locale. Inasmuch as non-insectan aquatic forms do show an adaptation, or at least a modification of their metabolism, with seasonal or latitudinal temperature changes (10, 11, 12, 25, 27, 28, 13, 7, 23), and inasmuch as it has been found in two aquatic insects that there is a possible change in seasonal metabolism (19, 21), it was thought quite logical to initiate a study of aquatic insects.

To this end a number of tropical, aquatic insects have been studied with the view of determining their metabolic response to a wide range of temperatures in different seasons, and their response to rapid, large changes in temperature. It was found that the insects used in this study show no, or only slight, metabolic adjustments to temperature changes.

Material and Methods

For the present experiments a number of species of Odonata, Hemiptera and Coleoptera were collected during the months of June, July and August during winter, and the months of January, February and March during summer from a small permanent pond on the outskirts of São Paulo. These comprised 6 species of larval Aeschnidae, 1 species of water bug (*Belostoma* spp.), 3 species of Dytiscidae, and a like number of Hydrophilidae (*Tropisternus collaris, T. lateralis* and *T. latus*). The animals were used one to two days after their arrival in the laboratory that they might be standardized in their nutritional condition and adaptation to laboratory conditions. They were not fed during the course of an experiment.

The oxygen consumption at rest was determined by means of volumetric microrespirometers (22). The oxygen consumption of a single individual per instrument was measured for at least one hour at each temperature, the results being given in the standard form of the Q_{o2}, i.e., mm^3 O_2 / mg fresh weight / hour. The procedure followed was to first place the animal inside a shell vial just slightly larger than the animal itself, fill the vial with sufficient water to cover about one fourth of the animal, and then attach the whole to the oxygen port of the respirometer. Carbon dioxide was absorbed by the commercial absorbent, Ascarite, placed in a small cup inside the vial and attached to the under side of the rubber stopper of the oxygen port. An equilibration period of 8 to 15 minutes was allowed in the water bath before closing the system and beginning the definitive readings.

Two types of experiments were performed. In the first the oxygen consumption was determined, in winter and in summer, at each of a number of temperatures from 1° to 40°C; the animal being left a minimum of 1 and 1/2 hours at each temperature. In the second series of experiments, in winter only, the oxygen consumption was determined at 21°C for one hour, then the animals (instruments and all) placed

in a second water bath at 6°C for one and 1/2 hours, then returned to the original temperature for a further measurement of 1 and 1/2 hours. In addition to the oxygen consumption measurements, observations were made of the lethal temperatures. For this purpose two methods were applied. Firstly, the animals were observed at the low and high temperatures while in the respirometers and their activity and respiratory

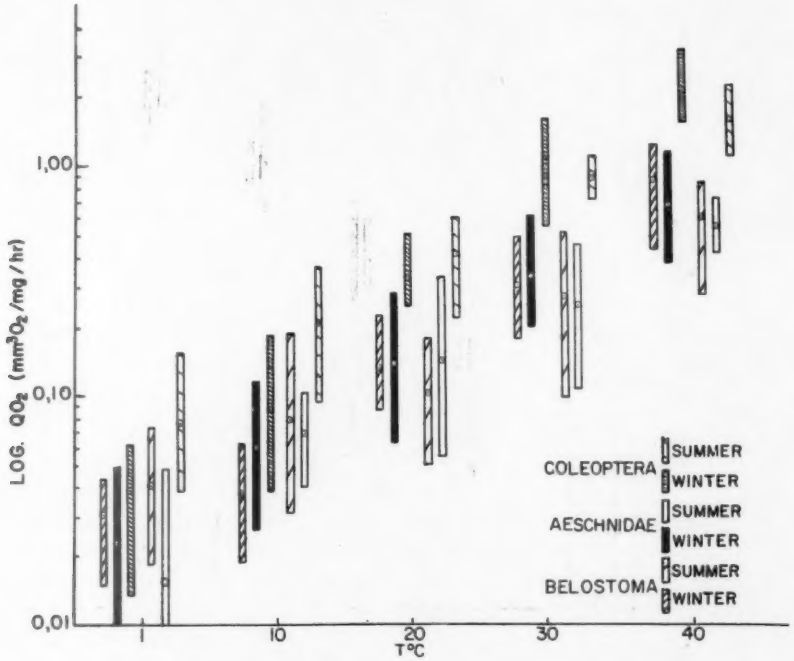

FIG. 1. — *Composite graph on semilogarithmic scale of winter and summer oxygen consumption of three groups of tropical, aquatic insects at graded temperatures from 1 to 40°C.*

rates correlated. Secondly, large numbers of animals were placed in small vessels which were then suspended from the sides of the aquaria at the various temperatures and the time taken for them to become inactive and to show signs of apparently irreversible damage, such as turning over on their backs.

RESULTS

1.) *Oxygen consumption at graded temperatures.* — The total results of the measurement of oxygen consumption at graded tempera-

tures are given in Fig. 1, where we have presented the averages, and the spreads, of oxygen consumption rates for all three groups of insects in both winter and summer. It is immediately evident from inspection of the curves that all points fall on a single curve, the slope of which is similar to that reported for all other insects. There is considerable spread

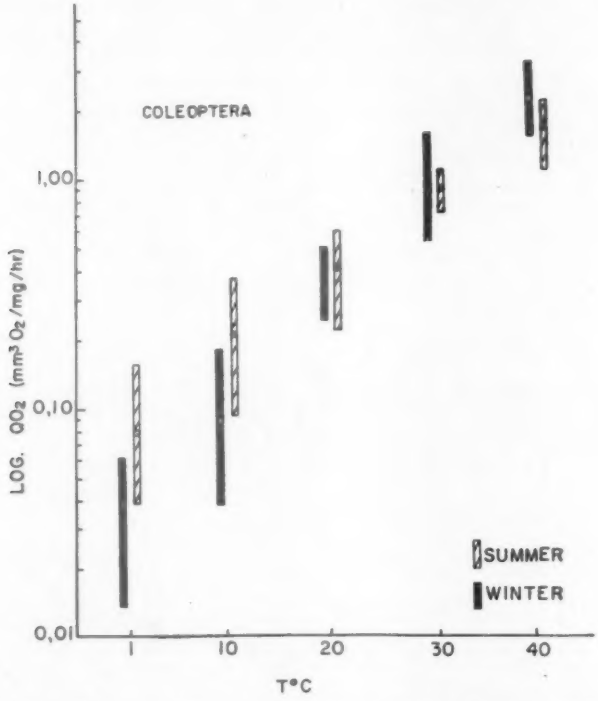

FIG. 2 — *Semilogarithmic graph of oxygen consumption of 6 species of Dytiscidae and Hydrophilidae in winter and summer over temperature range of 1 to 40°C.*

at any given temperature; the spread being no greater, however, in one season than in the other. The curve drops off at the higher temperatures, as has been previously shown for the response of other insects to temperature increases. Although there appeared to be no separation of the curves according to season, there was a definite separation according to order. The beetles showed consistently a higher oxygen consumption than the aeschnid larvae and the *Belostoma,* which were about equal in their rates. The reason for these differences is not yet evident. The differences apparently are not due to size alone. At each temperature 10 to 12 representatives of each group were used. The beetles varied in size from 26 to 217 milligrams, with an average weight of 96 mg.

The water bugs had an average weight of 1100 mg, with a range from 189 to 2440; whereas the average dragon fly larva weighed 520 mg, with a range from 37 to 1020 mg. The animals were chosen to give as great a spread of weights as possible, with no preponderance on either the high or low side. Thus, on the basis of weight alone, one would expect the

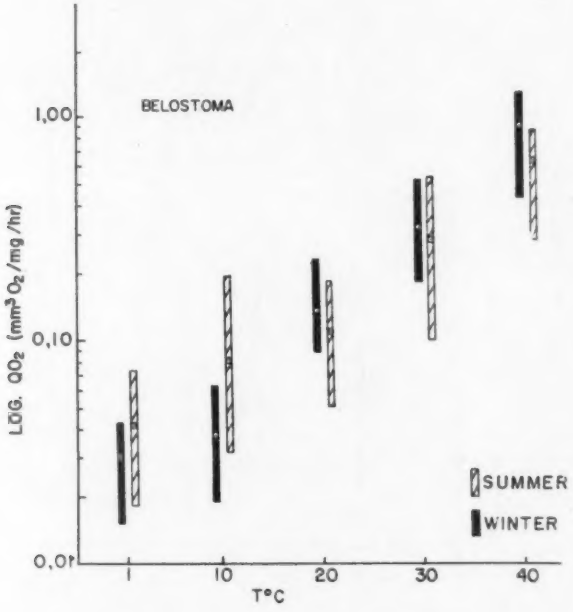

FIG. 3. — *Semilogarithmic graph of winter and summer oxygen consumption of* BELOSTOMA *spp. in range of temperature from 1 to 40°C.*

beetles to have the highest rate of oxygen consumption, the dragonfly larvae a medium rate and the water bugs the lowest rate. However, at all temperatures the rates of oxygen consumption of the dragonfly larvae and the water bugs were practically identical. A discussion of this point will be presented later in the paper.

To obtain a clearer picture of the seasonal rates of oxygen consumption, the results have been graphed according to the individual orders (Figs. 2, 3, 4). From these curves it will be seen that there is little, or no, significant difference between the winter and summer rates in the three groups. It is noticeable that the rate of oxygen consumption at the lower temperatures in winter was slightly lower than that in summer, and also that at the higher temperatures the animals showed a bit higher rate of oxygen consumption in winter than in summer. Thus,

although there is no definite tendency during any one season, or definite shift of curve from one season to the next, it is possible to deduce that the winter animals were the more sensitive to the temperature changes.

2.) *Effect of large, sudden changes of temperature.* — A second, possible method of determining if an animal is capable of metabolic adjustment is to expose the animal to sudden and large temperature changes;

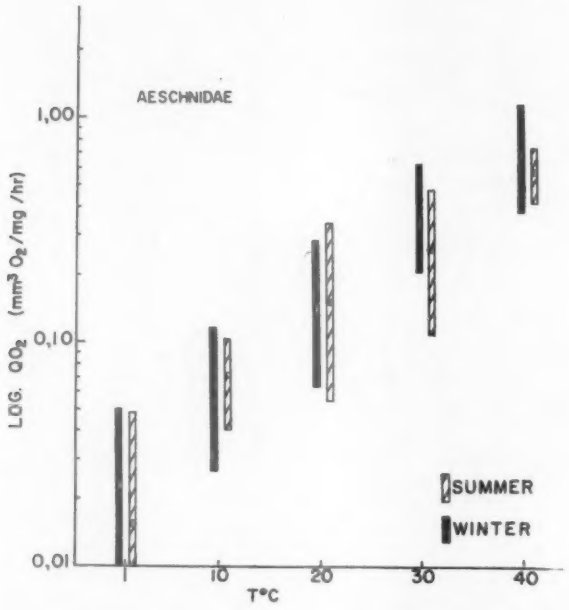

FIG. 4. — *Semilogarithmic curve of oxygen consumption of 6 species of larval Odonata during winter and summer at temperatures from 1 to 40°C.*

measuring the metabolism before, during and after the exposure. Thus, it has been shown in the sand crab (7) and other limited poikilo- or homeometabolic species, that rapid changes of more than 10°C cause an overshoot, i.e., after exposure to such a temperature change and return to the original temperature the oxygen consumption becomes greater than that normally at the initial temperature, with a gradual return to normality over a period of hours, the return time depending upon the length of exposure. In insects, however, as for example *Formica rufa* (4) and *Musca domestica* (5), it has been found that changes of as much as 18°C do not disturb the metabolic reponse to the initial temperature.

In the present experiment the insects were dropped (2 minutes to exchange from one temperature to the next) from 21° to 6° and returned again to 21°C. Six dragonfly larvae, 7 water bugs and 10 beetles

TABLE I

Influence of rapid, large changes of temperature upon the respiration of tropical aquatic insects in winter

Exp. n°	1	2	3	4	5	6	7	8	9	10	
					mm^3 0_2 / mg / hr						
Temp.					**Dytiscidae and Hydrophilidae**						**Average**
21	0.509	0.491	0.535	0.503	0.431	0.205	0.314	0.285	0.526	0.218	0.402
6	0.337	0.165	0.130	0.146	0.074	0.067	0.066	0.169	0.113	0.075	0.134
21	0.245	0.419	0.466	0.445	0.438	0.368	0.337	0.285	0.446	0.235	0.368
					Belostoma **spp.**						
21	0.100	0.128	0.208	0.112	0.121	0.226	0.190				0.155
6	0.040	0.034	0.038	0.048	0.044	0.039	0.029				0.038
21	0.066	0.139	0.161	0.132	0.124	0.219	0.238				0.153
					Aeschnidae						
21	0.210	0.190	0.256	0.156	0.113	0.179					0.183
6	0.040	0.034	0.064	0.039	0.023	0.041					0.042
21	0.166	0.155	0.215	0.124	0.147	0.157					0.161

were so treated; the results being presented in Table I. The animals were left at each of the temperatures 1 and 1/2 hours, the oxygen consumption being measured in each beginning at 8 minutes after the exposure (time necessary for temperature equilibration of the instruments). The animals used were those captured in winter. Inasmuch as no changes in respiratory pattern were observed the experiment was not repeated with the summer animals. No deviation from the original oxygen consumption occurred after the exposure, i.e. the insects exhibited only a smooth response to the changes in temperature. The beetles had an original rate of 0.402, dropped to 0.134 at 6° and returned to 0.368 at the original 21°C. Similar results obtained with the other two groups; the water bugs dropping from 0.155 to 0.038 and return to 0.153, and the dragonfly larvae from 0.183 to 0.042 and back to 0.161. In their activity the insects showed also no significant changes. On exposure to 6°C they became less active, but on return to the original temperature regained normal activity immediately.

3.) *Temperature coefficients.* — The temperature coefficient of an organism may have an adaptive meaning. An organism with a low Q_{10} would be expected to withstand temperature changes better than one with a high temperature coefficient, i.e. to show smaller respiratory changes per unit of temperature change. Such an adaptation should be of great advantage in temperate and desert regions where the daily and seasonal changes are considerable. It has been suggested that such an adaptive mechanism occurs in the polar cod (18), although this should hardly be an advantage as the polar cod lives in waters of rather constant temperature. In a survey of the literature on the subject (23), Scholander et al. found no case where a low Q_{10} indicated an adaptation by an animal to temperature change, and in fact in several cases there was found a high Q_{10} in animals living in environments where the seasonal changes in temperature were great.

Examination of our data (Table II), by calculation directly from the raw data $\frac{\text{rate at T°C}}{\text{rate at T - 10°C}}$ or by derivation of the values from the slopes of the curves on a semilogarithmic plot, shows that the aquatic insects studied in the present experiments were essentially no different from other insects in respect to temperature coefficient. The coefficients lay between 2.04 and 2.86 on the average. These values compare well with the values of 2.3 and 2.9 for arctic and tropic insects respectively, as found by Scholander et al (23). Thus, the values of Q_{10} for the tropical, aquatic insects studied to date indicate no adaptive mechanism of this type.

4.) *Lethal temperatures.* — The temperatures at which insects are permanently affected vary considerably. Certain insects, such as *Thermobia,* can withstand temperatures up to 51°C (9). On the other hand arctic insects such as *Croesus* (14) and *Borecellus* (23), or glacial forms, such as *Grylloblatta* (9), can withstand temperatures considerably below zero. In general, however, the range of temperatures acceptable to insects lies between 5 and 40°C; outside of this range the insects showing permanent damage. As with the vertebrates (24), the arctic invertebrates,

TABLE II

Temperature coefficients of tropical, aquatic insects at temperatures from 1 to 40°C in winter and summer

Season	**1 - 10°**		**10 - 20°**		**20 - 30°**		**30 - 40°**		**Average**	
Temp.	*winter*	*summer*	*winter*	*summer*	*winter*	*summer*	*winter*	*summer*	*winter*	*summer*
Animal										
Dytiscidae and Hydrophilidae	2.27	2.72	3.95	1.96	2.67	2.21	2.57	1.82	2.86	2.43
Belostoma **spp.**	1.30	1.95	3.60	1.33	2.30	2.67	2.90	2.22	2.52	2.04
Aeschnidae	2.61	4.50	2.32	2.13	2.48	1.74	2.01	2.23	2.35	2.65

including the insects, are able to withstand a larger range of temperatures than can the tropical forms (23).

In the present experiment a large number of individuals from each group of insects were exposed, both in the respirometers and in separate vessels, to temperatures from 1° to 45°C. The results were similar for both winter and summer insects. In the range of 5° to 40° the insects showed no permanent injuries. At 45° the dragonfly larvae became inactive and appeared dead almost immediately. The beetles turned over on their backs, apparently permanently inactive, within 3 minutes, and the water bugs within 10 minutes. The break in response was rather abrupt as the insects were able to withstand 44° from 1 to 4 hours, and indeed one group of water bugs, after an exposure of 3 hours to 44°, returned to normal activity when brought back to room temperature. At the lower end of the scale the death point was not registered. At 1° 25% of the beetles showed a decrease in oxygen consumption during the second hour of exposure, the others continuing at the initial rate and recovering completely on return to room temperatures. The water bugs and dragonfly larvae became inactive at 1°, but their oxygen consumption remained constant for two hours, and their oxygen consumption and activity became completely normal once again on return to room temperature.

Discussion

The present results serve to fill one of the previously existing gaps in our knowledge of temperature responses in insects, and they agree completely with previous results on the terrestrial insects. Although other aquatic, poikilometabolic animals may show a metabolic adaptation to temperature changes in the environment, generally by a shift of the M - T curve, the tropical, aquatic insects studied in the present experiments showed no evidences of other than a single M - T curve for both winter and summer. Several slight variations from a straight line may be noted in the results, but these cannot be construed as indicative of metabolic adaptation. The spread of values for a given group of insects was greater at the lower temperatures. There are several possible explanations of this fact. As has been found in the silkworm (20) and in *Galleria mellonella* (1), sex differences may disappear with increasing temperature, and it is possible that species differences may also disappear as the lethal temperature is approached. This latter explanation may well be the case, as in our experiments the lethal temperature seemed to be the same for all three groups, betwen 44 and 45°C.Analyzing the results separately by orders, it was found that there was a slight difference in slope of curve between winter and summer. The two seasonal curves cross each other, the slope of the summer curve being the lesser, indicative of lower temperature coefficients. This may be indicative of a very slight adaptation by the mechanism of change of temperature coefficient, and may be also a confirmation of the results of Poljakov (19) who showed that the time of the maximum daily oxygen consumption of Dytiscus shifts slightly with the seasons. Such slight variations,

however, are insignificant in comparison with the extreme shifts in M - T curves made by other aquatic poikilometabolic animals (5, 7, 23).

The effect of sudden changes in temperature may demonstrate the ability of an organism to make metabolic adaptations. In those organisms that show seasonal shifts in oxygen consumption, e. g. *Emerita talpoida,* a change in environmental temperature of more than 10°C causes an overshoot, or undershoot, on the return to the initial temperature. Similar adjustments have been found in various metabolic processes in other organisms, e.g. intestinal protozoa of termites (2), in bacteria (3), morphogenetic pathological fungi (16), in the metabolism of warm spring fishes (26), and the pulsations of the scyphomedusa, *Cassiopeia* (15). Other organisms, that do not normally show a seasonal or other type of variation with temperature changes, normally demonstrate only a smooth response in rate as a function of rapid temperature jumps, e.g. *Talorchestia* (8), *Musca domestica* and *Melanotus communis* (5). Thus, to date, all insects studied have exhibited a single type of response metabolically, whether the change in environmental temperature be rapid or slow, small or large.

Specific differences in rate of oxygen consumption were encountered in the present study; the beetles having the highest rates, and the dragonfly larvae and water bugs lower but similar rates. These differences cannot be due to differences in weight alone, as the average dragonfly larva weighed 520 mg, and the average water bug 1 100 mg. An explanation may be found, however, in the normal activity of the insects concerned. The beetles are not only small but extremely active; continuously darting rapidly about, and only seldom attaching themselves to each other or to other objects in the water. The dragonfly larvae and the *Belostoma,* on the other hand, appear to be normally quite lazy; remaining a great part of the time attached to plants or clumped together. In activity the dragonfly is the less rapid of the two, i.e. it can shoot forward at great speed due to its jet propulsion from the rectal gill, but *Belostoma* appears to be capable of more rapid muscular movement. It therefore seems probable that the resting metabolism of an organism is more nearly related to the rapidity of normal muscular response rather than to the quantity of activity.

Conclusions

The oxygen consumption of 6 species of Aeschnidae, 1 species of *Belostoma,* and 3 species each of Dytiscidae and Hydrophilidae has been measured by microrespirometers as a function of graded and rapid changes in environmental temperatures, in winter and summer. Temperature coefficients have been determined for the two seasons and observations made upon the lethal temperatures.

In all species the oxygen consumption over a graded series of temperatures from 1 to 40°C was the same in summer as in winter,, and a single M - T curve expresses the relationship for all species. There was a slight tendency for these insects to be more sensitive to changes at the lower end of the scale, as indicated by a greater spread of values.

There was a slight shift of slope (Q_{10}) with the seasons, the lower values being encountered in the summer. The variations, however, were not sufficient to be considered metabolic adaptation to change in temperature.

All species showed only a smooth response to sudden, large jumps in temperature, a further indication of lack of metabolic adaptation.

The lethal temperatures for all species were 44-45°C at the upper end and less than 1°C at the lower end of the temperature scale. There occured no variation of thermal death points with change of season.

Species differences were found in the rates of oxygen consumption at any given temperature, the smaller and more active beetles exhibiting the highest rates, the slower and larger dragonfly larvae and *Belostoma* having lower, but similar, rates. It is concluded that the resting rate of oxygen consumption of an insect is related to the rapidity of normal muscular activity as well as to size.

ACKNOWLEDGEMENTS

This work was supported in part by a grant from the Rockefeller Foundation to the Depto. de Fisiologia Geral e Animal. We would like to express our appreciation of the interest and support given during the course of this study by Prof. Dr. Paulo Sawaya, chairman of the department.

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INTRAESOPHAGEAL PRESSURE AND THE LOCAL DIFFERENCES IN PLEURAL PRESSURE

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THE LUNGS, small organs of scarce density, must stretch considerably in order to fill the whole of the thoracic areas. For this reason a retraction force is created which determines a subatmospheric pressure (negative pressure) within the pleural virtual space. The first experimental basis of this concept is found in the papers by Carson (2) and Donders (3).

Evidently, pressure is the same in all points of the pleural cavity that has been made real by means of a large pneumothorax. But when the pleural space is virtual, local pressures may or may not be identical. Should the lung have no weight, should its form be similar, though smaller, to that of the space it occupies, and should it be equally retractile in all directions, all the pleural cavity, even if virtual, would have the same pressure. Actually these three conditions are only approximately fulfilled: the normal lung has a scarce density, its form is similar to that of the thorax, and it retracts in a fairly uniform way in all directions. On the other hand, the lungs can be pulled by the thick bronchi and the great vessels in an unpredictable sense and consequently determine local differences in pleural pressure.

The experiments of Wiggers and col. (8) and of Brookhart and Boyd (1) demonstrated that simultaneous pleural pressure curves in various small pneumothorax, though very similar in form, showed important quantitative differences. Parodi (7) sustains that because of lung weight, there is a continuous variation of pleural pressure in the vertical sense.

Received for publication August 3rd, 1954.

It is the purpose of this paper to obtain some information on the eventual variations in pleural pressure along the cephalo-caudal diameter of the thorax in the horizontal or vertical (head up) position, making use of the fact that the esophagus and the superior vena cava (S. V. C.) run contiguous to the mediastinal pleura and are therefore exposed to the pleural pressure during a long sensibly straight, stretch.

Actually, these experiments were carried out in dogs and comparisons were stablished: a) between pressure in a large or small pneumothorax, performed on the antero-external wall, and the esophageal pressure; b) between S. V. C. and esophageal pressures, both measured in points situated at the same height. Many obvious criticism can be made to this procedure but it is preferable to consider them further in the discussion.

Experimental Methods

Ten dogs, weighing between 15 and 25 kg, were anesthetized with 0.1 g/Kg chloralose and placed in a horizontal or vertical (head up) position. Pleural and intraesophageal pressures were recorded simultaneously by optical manometers of the Gregg (5) design (air transmission). Pleural pressure was measured by inserting a trocar through the thoracic wall. Esophageal pressure was measured by introducing a rigid catheter with an end opening into the esophageal cavity. The small air bubble at the end of the canula allowed a good transmission of intraesophageal pressure variations. With a sufficient extension of the head of the animal, the introduction of the catheter into the stomach presented no special difficulties; once introduced, it was retired by 2 cm long stretches and corresponding records were obtained.

The esophagus, while at rest, contains no air for two reasons: a) because of the collapsible character of the esophageal tube, thoracic hypopressure cannot produce the entrance of atmospheric air through the pharinx into the thoracic esophagus; b) the air that penetrates duduring deglutition passes into the stomach by peristaltic action. Therefore, the ligature of the cervical esophagus practiced by Luciani (6) in some similar experiments is completely unnecessary.

In another series of 4 experiments, esophageal and venous (along the S. V. C.) pressures were simultaneously recorded. Saline was used as manometric medium and the two rigid catheters were moved solidarily in the vertical direction, so that the two records corresponded to points at the same level of both vias in dogs in the vertical (head up) position.

Results

Fig. 1 shows four incomplete series of pleural and esophageal records (air transmission). *A* and *B* correspond to a dog in the vertical (head up) position; *C* and *D* to another dog in the horizontal position. The pneumothorax was large (300 cm^3) in *A* and *C* and minimal in *B* and *D*. Arrows *O* and *D* show the relative positions of the cervico-thoracic limit and the diaphragm respectively. The records show a good co-

rrespondence between both curves when the esophageal catheter is in the thorax; on the contrary, there is no correspondence when it is in the neck (no respiratory variations in *a* - *A* and *a* - *B*) and when it is in the stomach (abdominal pressure curve in *g* - *A* and *g* - *B*).

Diagrams of fig. 2 were built with data from the experiment of fig. 1 - *A* - *B* and two other similar experiments (vertical dogs). Values

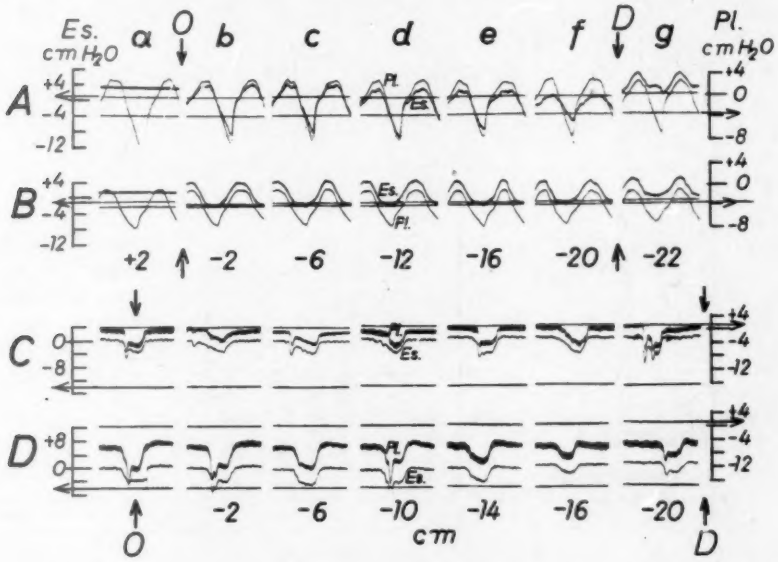

FIG. 1. — *Simultaneous records of pleural* (Pl) *and esophageal* (Es) *pressure.* A) *Vertical dog (head up) with a large pneumothorax.* B) *The same, with a small pneumothorax.* C) *Horizontal dog with a large pneumothorax.* D) *The same with a small pneumothorax. Figures under records indicate cm along the esophagus. Arrows* O *and* D *indicate the relative position of the cervico-thoracic limit and the diaphragm respectively. Calibration of the esophagus curves, to the left; calibration of the pleural curves, to the right.*

of *esophageal minus pleural pressure* (*E* - *P*) (abscissae) were plotted against *distances* (*L*) *along the esophagus* (ordinates). Tips of the arrows signal differences *E* - *P* at the end of inspiration, when pleural pressure is minimal; tails signal the same differences in the moment of maximal pleural pressure. Black arrows correspond to the experiments with a large pneumothorax and white arrows to those with the smallest possible pneumothorax. Bars *a* and *b* represent the mean amplitude of pleural pressure respiratory variations in both series of records.

Diagram I (fig. 2) shows: a) Both series of arrows are very small in the thoracic sector, specially if they are compared with bars *a* and *b;* furthermore their direction is variable. All this implicates the perfect

parallelism of both curves and the consequent absence of damping in the esophageal cavity. If the quotient between the average length of the arrows and of the bars *a* and *b* is taken as an index of damping, this index is of: 1.4 % in the large penumothorax and of 3.8 % in the small pneumothorax; logically, negative values have no real significance and

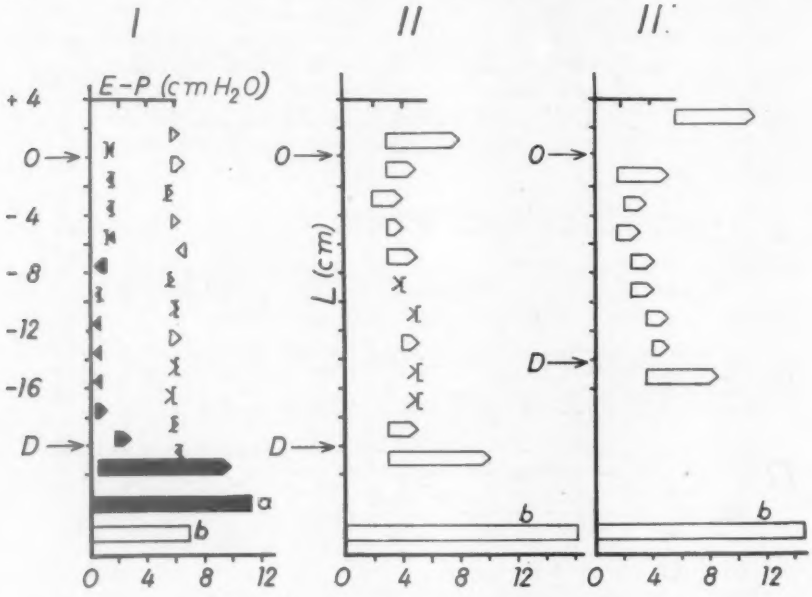

FIG. 2. — *Diagrams from three dogs in the vertical position (head up). Ordinates: distances* (L) *along the esophagus. Abscissae: differences* (E-P) *between esophageal and pleural pressures. The tips of the arrows indicate those differences in the moments of minimal pleural pressure; the tails, in the moments of maximal pleural pressure. Black arrows: large pneumothorax; white arrows: small pneumothorax. Bars* a *and* b *indicate the mean amplitude of the pleural pressure respiratory variations in large and small pneumothorax respectively* O *and* D *as in fig. 1.*

are due to experimental errors. b) Both series of arrows are vertical columns parallel to the axis of ordinates, indicating that the value *E - P*, and consequently the esophageal pressure, does not vary with height. This fact can only be coherent with the hypothesis that the expanded lung behaves as a gaseous medium identical to the one created by a large pneumothorax, at least in normal conditions, and along the mediastinum. c) The series of black arrows is found very proximate to the axis of ordinates, indicating that the intracavitary pressure of the esophagus is very proximate to that of the surrounding gaseous medium. On the other hand, the series of white arrows is found at a distance of about 5 cm from the same axis; this value, which cannot be attributed

to the tonus of the esophageal wall, must depend on the fact that the pleural pressure in the juxtaesophageal regions surpasses that in the anterolateral regions in 5 cm of water.

Diagrams II and III (fig. 2), though not so regular, are similar to the preceding one. Damping index was 6.2 and 11.8 % respectively. A

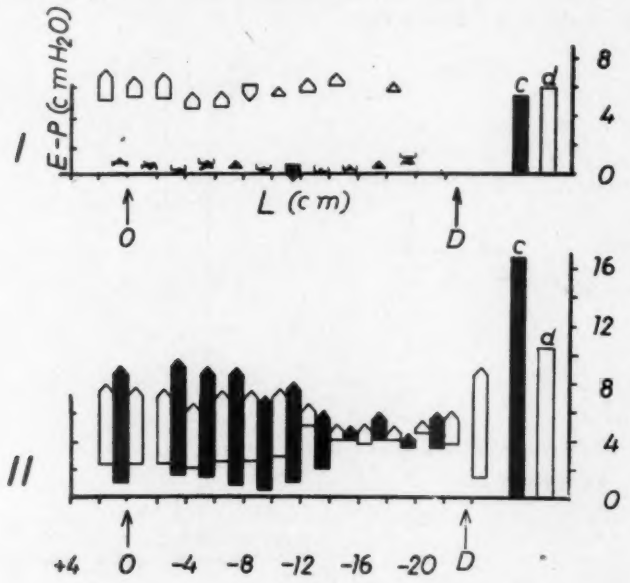

FIG. 3. — *Diagram from 2 dogs in dorsal decubitus. Abscissae: distances along the esophagus. Ordinate: E-P differences. Other conventions as in fig. 2 (c and d instead of a and b respectively).*

slight oblicuity of the column of arrows, suggesting a certain hydrostatic action of the lung, is apparent in experiment III.

Diagrams of fig. 3 were built with data from fig. 1 - *C* - *D* and another similar experiment (horizontal dogs). Conventions are those of fig. 2, except that abscissae represent distances *L* along the esophagus and ordinates, the difference *E* - *P*.

Diagram I (fig. 3) shows: a) All arrows are small, specially if they are compared with the amplitude of bars *c* and *d* (respiratory variations of pleural pressure); the index of damping is of only 1.3 % for the large pneumothorax and of 16 % for the small pneumothorax. b) Arrows form two practically horizontal series, which implicates the homogeneity of the paramediastinal medium, but does not necessarily mean

that this medium is of a gaseous nature since all determinations were made in the same horizontal plane. c) The series of black arrows is found very proximate to the axis of abscissae, thus indicating the scarce value of the esophageal intracavitary pressure; on the other hand, the series of white arrows is found 5 cm from that same axis, thus confirming that, also in this experiment and in this position, pleural pressure in the paramediastinal region surpasses that in the anterolateral region in about 5 cm of water.

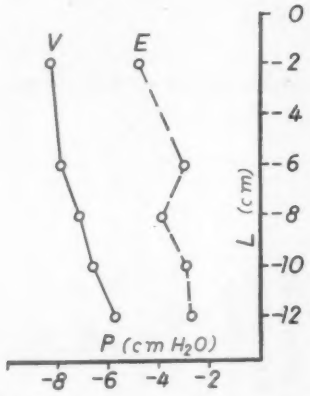

FIG. 4. — *Mean esophageal* (E) *and superior vena cava* (V) *pressures. Simultaneous records at different levels in vertical* (*head up*) *dogs. Abscissae O: Atmospheric pressure. Ordinate O: Cervico-thoracic limit. Average of four experiments.*

Diagram II (fig. 3) illustrates one of the different atypical results that were obtained in this experimental series. The index of damping is small in the distal portion of the esophagus (9 % in the small pneumothorax, 10.2 % in the large one) and it is quite considerable in the proximal portion (45.8 and 47.1 % respectively). Besides, extraesophageal pressure is not substantially modified by the institution of a large pneumothorax. All this suggests the existence of atypical anatomical circumstances that in this particular case separate the mediastinal pleura from the esophagus, specially in its proximal portion.

It is the purpose of the next series of experiments to check the method of the esophageal catheter by introducing another catheter in the S. V. C. The extremities of both catheters are found at the same level in collapsible tubes of small or null intracavitary pressure that are presumably contiguous to the mediastinal pleura, in vertical dogs. The venous method has the advantage of a more ample and sure contact of the S. V. C. with the pleural cavity, but has the inconvenients derived from the auricular activity (4). The esophageal method is just in the

opposite situation. Mean pressures (measured with a planimeter) were considered.

The diagram of fig. 4 represents the average results from four experiments. Venous and esophageal pressures (abscissae) were plotted against heights of determinations (ordinates). Ordinate *O* corresponds to the cervico-thoracic limit; abscissa *O*, to the atmospheric pressure. Venous pressure (*V*) increases regularly downward due to auricular activity and/or to a small hydrostatic action of the lung. Esophageal pressure (*E*) varies somewhat irregularly and surpasses the pressure in the upper portion of the S. V. C. (where the venous pressure is not affected by auricular waves) in about 4 cm of water. All this can be interpreted as consequence of the imperfection of the esophageal method in a random series of experiments.

Discussion

From the above results, it seems evident that there are some particularly favorable circumstances in which intraesophageal pressure can be a faithful expression of pleural pressure. It can be thought that this occurs when the esophagus is in immediate contact with the pleura, when its cavity is virtual and when the tonus of its walls is very small. On the other hand, there are some other not so favorable circumstances in which intraesophageal pressure is a distorted expression of the pleural pressure. It can be assumed that this occurs when, because of relative small anatomical variations, the esophagus is separated from the pleural contiguity, when it is distended by an air bubble and when its tonus increases. The muscular tonus factor is not important, or at least not constant, as shown in diagram of fig. 2 - *I* - *II* and 3 - *I*. Besides, peristaltic movements are only transitory events that can be easily excluded. The existence of intraesophageal gaseous bubbles is difficult to accept as a cause of durable disturbance, because such bubbles would be rapidly impelled to the stomach by virtue of reflex peristalsis. The hypothesis according to which damping would be due to some deviation of the standard position of the esophagus in the mediastinum is favored by the following facts: a) From the anatomical point of view, the esophagus is an intramediastinal organ with rather accessory pleural contacts that can change from one subject to another. b) In some experiments like in the case of fig. 3 - *II*, damping has a well localized and constant character. c) The esophageal pressure line in fig. 4 shows certain irregularities that contrast with the perfect continuity of the venous pressure line.

On the basis of very favorable experiments like those of fig. 2 - *I* - *II*, it can be deduced that pressure in the pleural cavity suffers no systematic variations along the cephalo-caudal diameter of the thorax in the vertical (head up) position of the animal, and consequently lung weight does no exert appreciable influence upon the distribution of pleural pressure. In other words, the thoracic medium behaves like a homogeneous gaseous medium, at least in the paramediastinal regions. This concept

is probably not affected by figure 2 - *III* and the random series of fig. 4.

The same favorable experiments confirm the higher values of the mediastinal versus the antero-lateral pleural pressures referred by Brookhart and Boyd (1).

Summary and Conclusions

The esophagus, whatever the positions of the animal, and the superior vena cava, in the erect position, behave like collapsed tubes running along the mediastinal pleura; therefore they allow a systematic study of the pleural pressure along the cephalo-caudal diameter of the thorax. Optical records of pressure in a pneumothorax (large or small) or in the superior vena cava, were obtained simultaneously with esophageal pressure in horizontal or vertical (head up) dogs.

In some specially favorable experiments the following facts were observed: a) The curves of esophageal pressure showed no important damping. b) Effective intraesophageal pressure was insignificant. c) Intraesophageal (paramediastinal pleural pressure) surpassed antero-lateral pleural pressure in about 5 cm of water. d) Lung weight had little or no influence upon local pleural pressure.

In other not so favorable experiments, the esophageal curves were irregularly damped due to probable individual anatomical conditions. Because of damping, mean esophageal pressure surpassed S. V. C. pressure in about 4 cm of water in a random series of 4 experiments.

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ZONAL "BASOPHILIC PITUITOGRAM" OF THE ANTERIOR PITUITARY GLAND OF THE NORMAL MALE RAT

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MANY INVESTIGATORS have shown that the cells of the anterior pituitary gland have a characteristic zonal arrangement. The anterior lobe of the cattle pituitary shows a very sharp systematization: it has a central part with chromophobes and basophile cells and a peripheral zone remarkably eosinofilic. This uneven distribution of the cell types made possible to test the hormonal content of both zones and to ascribe specific hormones to the basophile cells (Smith and Smith, 1923; Schooley and Riddle, 1938; Friedman and Hall, 1941; Smelser, 1944). Halmi (1950-52), using the aldehyde-fuchsin with azan (Gomori, 1950), has described, in the pituitary of the rat, two types of basophile cells, delta cells, in the periphery of the gland and beta cells in the central part.

Purves and Griesbach (1951 a), with the Mac Manus-Hotchkiss method, and with the Gomori technique (1951 b), have described two types of basophile cells: a) thyrotrophs located in the core of the gland and b) gonadotrophic cells in the periphery. Later, these two investigators (Purves and Griesbach, 1952) found two types of gonadotrophic cells in the rat pituitary, one central type and another located in the periphery. These authors suggested that the peripheral gonadotrophs might produce follicle-stimulating hormone and the central cells, luteinizing hormone.

Ferrer and Pellegrini (1952), studying the morphological aspect of the nucleus, Golgi's apparatus and cytoplasm of the basophilic cells of the anterohypophysis of male rats described a functional or maturative sequence with 10 well differentiated stages; two series, the normal and

* This work has been done during the tenure of a scholarship of Asociación Argentina para el Progreso de la Ciencia.

Received for publication August 14th, 1954.

the vacuolated inmature, were established with a total amount of 54 elements.

The percentages of the different cell types gave typical curves for normal, castrate, adrenalectomized and thyroidectomized animals. The differential count was performed in the whole adenohypophysis.

In the present work the pituitary gland of the rat has been divided into 4 zones and a basophilic pituitogram has been performed in each.

The results give support to the contention that there are zones with different and constant maturative levels.

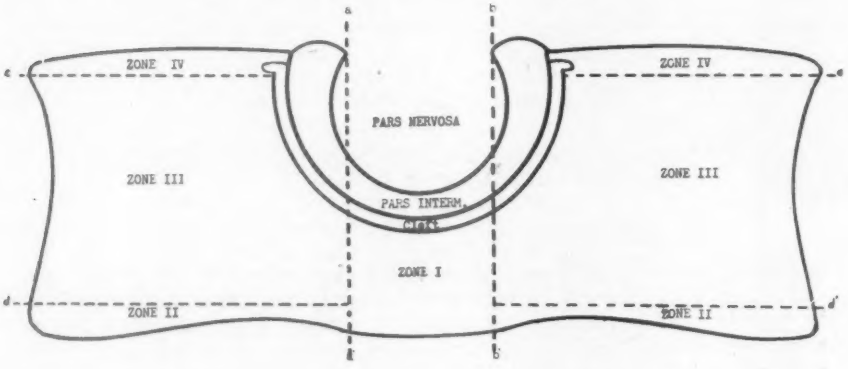

FIG. 1. — *Coronary diagram of the middle part of the rat pituitary gland. The lines a-a' and b-b' are perpendicular to the superior edge in the junction of the pars intermedia and the neural lobe. These two lines separate the zone 1. The dotted lines c-c' and d-d' are the imaginary boundaries of zones 2, 3 and 4.*

MATERIAL AND METHODS

10 normal male young adult rats were used. The animals were sacrificed under ether anesthesia. The pituitaries were removed immediately after death and fixed in Zenker-formaline. Coronary slices 5 microns thick were cut in the middle part of the pituitary gland and were stained with the Mac Manus-Hotchkiss' technique.

The inferior edge of the pituitary was divided into three parts by two parallel lines starting from the junction of the pars intermedia and the posterior lobe in the superior edge and going down to the inferior edge of the hypophysis. The pars distalis, consequently, was divided into three areas. Zone 1 was limited by the inferior edge, the two lines just described and the epithelium of the cleft. The zones number 2 were located at both sides of the former, their upper margins had no clear cut limits; these zones had a lower height than the precedent. Only the basophils of the border were counted (Fig. 1). The zones number 3 occupied the central part of the gland. The zones number 4 are

located at both sides of the pars intermedia, on the superior border of the pituitary gland; they had no clear cut limit in its inferior edge; only the basophilic cells of the border were included.

A Basophilic Pituitogram, as previously reported (Ferrer and Pellegrini, 1952), was performed in each of them, counting 100 elements per zone. The mean and its fiducial limits of 95 % were estimated.

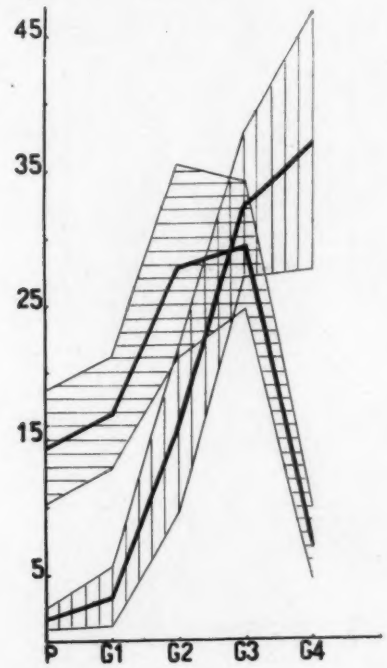

FIG. 2. — *Means and fiducial limits of 95 % of the zones 1 and 3.*
=: *zone 1*
|||: *zone 3*

RESULTS

The vacuolated cells of the Normal Series and all the elements of the Inmature Series were excluded because they showed no difference among the zones. The elements used in this study were then: Primordial cells (P), Golgi 1 cells (G 1), Golgi 2 cells (G 2), Golgi 3 cells (G 3), and Golgi 4 cells (G. 4), the Golgi 4 final (G 4F), were added to the previous group.

A striking difference was found among these zones: the most inmature one was the first, which showed, compared with the other ones,

a deviation to the left, i.e.: an increase in the proportion of the P, G 1 and G 2 cells and a significantly lower G 4 count.

The central part, zone 3, was the most mature showing a lower P and a higher percentage of G 4 cells.

These two zones (Fig. 2), namely one and three, were significantly different.

Zones 2 and 4, on the other hand, showed similar levels and no significant difference was found between them (Fig. 3). Their maturative levels were intermediate between the other two zones. The amount of the G 3 cells did not differ significantly in the different zones and they stood as an axis for their deviations to right and left.

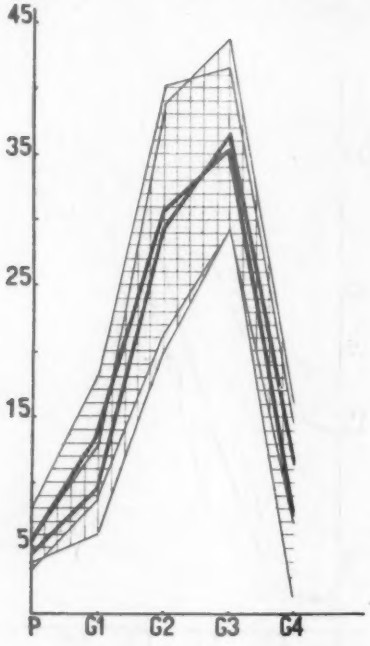

FIG. 3. — *Means and fiducial limits of 95 % of the zones 2 and 4. The means and their fiducial limits averlap almost everywhere.*
=: *zone 2*
|||: *zone 4*

DISCUSSION

The Basophilic Pituitogram of normal male rats showed a significantly different maturative level according to the zones where it was performed. In consequence, the separation in zones seems to be warranted.

We believe that all the elements which form the two basophilic series, as previously described (Ferrer and Pellegrini, 1952), do not undergo all the possible changes of these series, perhaps they remain preferently in particular stages in each zone.

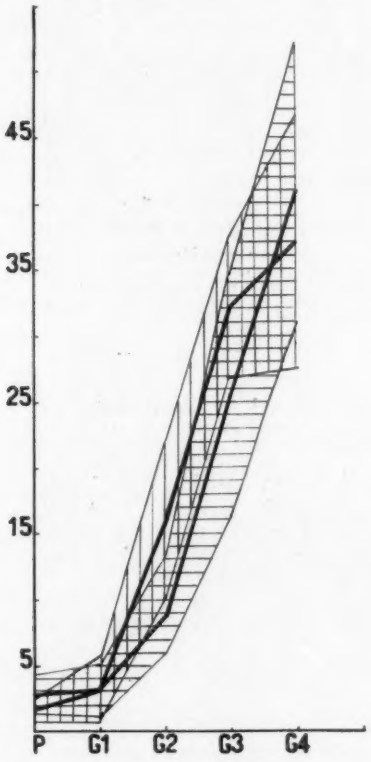

FIG. 4. — *Means and fiducial limits of 95 % of the zone 3 and of the Basophilic Pituitogram as previously reported. The means and their fiducial limits of 95 % overlap almost everywhere.*
=: *Basophilic Pituitogram.*
|||: *zone 3.*

The mean Basophilic Pituitogram of these zones is significantly different from that taken as normal previously (Ferrer and Pellegrini, 1952). The latter shows a strong deviation to the right, it is nevertheless remarkably alike the Basophilic Pituitogram of the third zone (fig. 4). We believe that this result is due to the use of a different technique; in 1952 the basophilic cells were counted from border to border through

the center, over wide lines, as in blood smears. By this way the number of the basophilic cells of the zones 1, 2 and 4, specially the former, has a slighter contribution than the third zone.

Other investigators (Halmi, 1950; Purves and Griesbach, 1951 a, b; 1952), taking into account many elements as: stain sensitivity, affinity to the blood vessels, form, size, reaction to hormones, etc., described regional differences and ascribed to them an endocrine significance. They did not substantiate, however, their findings on quantitative grounds with the precision achieved with the method just described, which seems to afford a more sensitive estimation of small changes in the basophilic picture of the pituitary.

A study now in progress, indicates a specific zonal variation in several treatments.

Six days after gonadectomy zone 1 shows a picture similar to the zone 3, and zones 2 and 4 are drawn back to zone 1 by adrenalectomy.

It is possible that further studies may allow to correlate small differences in the zonal Basophilic Pituitogram to different slight endocrine alterations.

Summary

Four distinct areas have been demarcated in the anterior pituitary of normal male rats studying coronary slices taken from the middle part of it.

A Basophilic Pituitogram has been performed in each of them and 3, out of 4, showed constantly different maturative levels.

The zonal differential count affords a more sensitive estimation of small changes in the basophilic picture of the pituitary.

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ESTUDIOS HEMATOLOGICOS EN MUJERES ADULTAS SANAS

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El presente trabajo tiene por objeto contribuir al conocimiento de algunas constantes hematológicas en mujeres adultas, sanas, residentes en Lima (altitud: 150 metros). Es obvia la importancia de contar con una escala de valores que represente las cifras hematológicas en mujeres de nuestro medio, pues tanto la clínica como la investigación científica necesitan de esta base comparativa para juzgar la magnitud de las desviaciones patológicas sanguíneas con base racional, eliminando, hasta cierto límite, factores tales como alimentación, raza, clima, etc. Además, en un país como el Perú, con una gran masa de población que vive a grandes alturas sobre el nivel del mar, es indispensable poseer cifras hematológicas correspondientes a mujeres del nivel del mar como base para valorar el efecto de la anoxia sobre el equilibrio hematopoyético.

En 1936 Hurtado y col. (1) y posteriormente Hurtado, Merino y Delgado (20) publicaron sus estudios sobre el cuadro hemático normal realizados en hombres sanos de nuestro medio. Estudios similares llevaron a cabo, posteriormente, Guzmán Barrón y col. (2). Estos trabajos han servido hasta ahora como una base de comparación tanto en la clínica como en estudios de investigación que se han hecho entre nosotros. Pero es comprensible que estos patrones carezcan de valor comparativo cuando se realizan estudios en mujeres, ya que es bien conocido que el sexo juga un papel importante sobre las constantes hematológicas.

Material y Métodos

Los diferentes estudios, en sangre periférica, se llevaron a cabo en 150 mujeres, aparentemente sanas, de raza mestiza, la gran mayoría de

Recibido para su publicación el 3 de septiembre de 1954.

las cuales procedían de la costa y cuyas edades fluctuaban entre 14 y 29 años, estando el 73 % entre 17 y 20 años de edad. De estos 150 casos, 63 fueron estudiados por Hurtado y Merino en huérfanas del Orfelinato de Magdalena; 29 por Delgado Febres en postulantes a la Escuela Nacional de Enfermeras, y los 58 restantes por Picón Reátegui en 14 postulantes a la Universidad Mayor de San Marcos y en 44 postulantes a la Escuela Nacional de Enfermeras *.

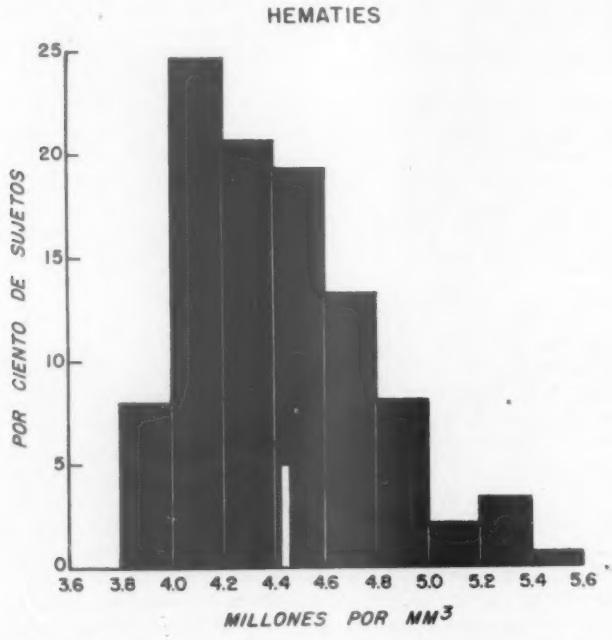

FIG. 1. — *Distribución de la concentración de hematíes por mm³ en las 150 mujeres adultas estudiadas.*

Las muestras de sangre fueron tomadas en ayunas por punción de una vena de la flexura del codo, teniendo cuidado de aflojar la ligadura una vez introducida la aguja dentro de la vena, depositándose 5 cc de la sangre en una botella conteniendo 6 miligramos de oxalato de amonio y 4 miligramos de oxalato de potasio secos (3). La primera gota expelida por la aguja, inmediatamente después de hecha la punción venosa, sirvió para hacer dos extensiones en láminas portaobjetos limpias, las que eran coloreadas con colorante Wright para hacer la fórmula diferencial leucocitaria siguiendo la clasificación de Schilling (4) y contando 200 elementos blancos en cada caso. En la sangre oxalatada se hizo las si-

* Estos estudios han sido agrupados en un solo trabajo a causa de que los estudios estadísticos no mostraron ninguna diferencia significativa, a pesar de que han sido efectuados en distintas épocas y por diferentes invesigadores.

guientes determinaciones: número de hematíes y de leucocitos por milímetro cúbico, usando pipetas calibradas por el Bureau Standard de U. S. A. y una cámara doble de Neubauer. En todos los casos se hizo una doble cuenta globular, tomando el promedio como cifra final. El número de reticulocitos, por ciento, se obtuvo en preparaciones húmedas, siguiendo el método descrito por Dameshek (5). El hematocrito se deter-

TABLA I

Valores hematológicos obtenidos en 150 mujeres sanas residentes en Lima

	Media ± E.S.	Desv. St. ± E.S.	Coef.Var. %	Variaciones extremas
Hematíes ..... (mill. por mm^3)	4.42 ± 0.03	0.34 ± 0.02	7.7	3.80 — 5.40
Hemoglobina ..... (Gms. por 100 cm^3)	13.99 ± 0.08	1.04 ± 0.06	7.4	11.05 — 17.10
Hematocrito ..... (por ciento)	41.5 ± 0.18	2.22 ± 0.13	5.3	35.9 — 46.5
Reticulocitos ..... (por ciento)	0.4 ± 0.36	0.39 ± 0.25	97.5	0.0 — 2.0
Vol. M. Corp. ..... (micras^3)	94.1 ± 0.50	6.17 ± 0.36	6.5	76.4 — 109.3
Hb. M. Corp. ..... (micro-microgram.)	31.8 ± 0.20	2.49 ± 0.14	7.9	27.1 — 37.9
Conc. Hb. M. Corp (por ciento)	33.8 ± 0.13	1.65 ± 0.09	4.9	29.0 — 38.2

minó usando el tubo de Wintrobe (6), el cual era centrifugado por 30 minutos a 3500 r.p.m. en una centrífuga International, tamaño I, tipo SB. La determinación de la hemoglobina (gramos por 100 cc de sangre) se hizo empleando el colorímetro fotoeléctrico de Evelyn, previamente calibrado por el método de la capacidad de oxígeno de la sangre, en el aparato manométrico de Van Slyke (7).

El volumen medio corpuscular (micrones cúbicos), la hemoglobina media corpuscular (micro-microgramos) y la concentración de la hemoglobina media corpuscular (por ciento), fueron calculados de acuerdo con las fórmulas de Wintrobe (8).

El volumen sanguíneo se determinó en 8 mujeres, estudiantes de medicina, usando células rojas marcadas con P^{32} y siguiendo el método descrito por Hevesy y Zarahn (9), modificado por Berlin, Lawrence y Gartland (10). La edad de estas mujeres fluctuó entre 23 y 24 años.

Los resultados obtenidos en las diversas investigaciones han sido sometidos a un estudio estadístico.

Resultados

Los resultados obtenidos, en las diferentes investigaciones, están resumidos en las tablas I, V y VI.

Hematíes. — En la Fig. 1 representamos la distribución de las cifras de hematíes encontradas en 150 mujeres.

Hemos encontrado una cifra media de 4.42 ± 0.03 con variaciones entre 3.80 y 5.40 millones de hematíes por mm^3, como se puede apreciar en la tabla I.

Revisando la literatura americana y europea Osgood (11) encuentra un promedio de 4.85 y Wintrobe (12) 4.72 millones de hematíes por mm^3. En la tabla II consignamos una revisión de la literatura a nuestro alcance.

TABLA II

Cifras de hematíes en mujeres adultas sanas, encontrados por otros investigadores

Autor	N° de casos	Edad	Hematíes (mill. por mm^3)
Andersen y Mugrage (13) ..	45	20 — 45	4.63
Osgood (11)	152	14 — 30	4.83
Wintrobe (12)	50	17 — 30	4.93
Sachs y col. (14)	10	20 — 28	4.58
Sachs y col. (15)	29	14 — 18	4.62
Ohlson y col. (16)	4550	16 — 30	4.56
Leichsenring y col. (17) ...	258	12 — 19	4.15
Belk y col. (18)	25	——	4.70
Promedio			4.62

Como se puede apreciar, nuestros resultados son ligeramente inferiores a los promedios encontrados por la mayoría de los investigadores anteriormente citados, con excepción de Leichsenring y col. (17), quienes encontraron un promedio 4.15 millones de hematíes por mm^3.

Hemoglobina. — La Fig. 2 representa la distribución de las cifras de hemoglobina encontradas en 150 mujeres. La cifra media encontrada fué 13.99 ± 0.08 con variaciones entre 11.05 y 17.10 gramos por 100 cc de sangre. Osgood (11) haciendo una revisión de la literatura europea y norteamericana encuentra una cifra media de 13.9 gramos y Wintrobe (12) en una revisión semejante encuentra un promedio de 13.91 gramos de hemoglobina por 100 cc de sangre. La tabla III resume los datos encontrados en la literatura.

Como se puede ver, nuestros resultados concuerdan con los promedios de la mayoría de los investigadores anteriormente citados, con excepción de Leichsenring y col. (17) que dan un promedio bastante bajo. El promedio de 14.45 gramos por 100 cc encontrado por Andersen y Mugrage (13), probablemente sea debido a que estos investigadores llevaron a cabo sus determinaciones a una altura de 1 524 metros sobre el nivel del mar.

Guerrero (30) ha determinado la cantidad de hemoglobina en 210 niñas de 10 a 17 años de edad en un colegio particular y en Escuelas Fiscales de Lima y ha encontrado una media de 12.5 gramos para el

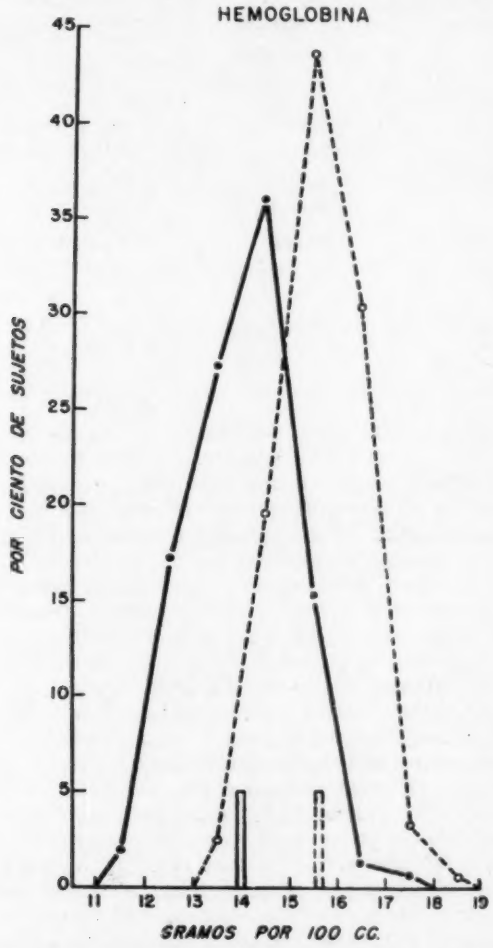

FIG. 2. — *Distribución de los valores de hemoglobina (gramos por 100 cc de sangre) en las 150 mujeres adultas estudiadas (línea continua), en comparación con idéntica investigación hecha en hombres adultos (línea interrumpida) (20). Ambas investigaciones fueron llevadas a cabo en Lima.*

grupo del colegio particular y 11.26 para el de las Escuelas Fiscales. En el grupo de las Escuelas Fiscales, evidentemente, hubo tanto un menor aporte, así como también una menor utilización de nutrientes, ya

TABLA III

Cifras de hemoglobina en mujeres adultas sanas, encontradas por otros investigadores

Autor	Método	N° de casos	Edad	Hemoglobina (Gm/100 cc)
Andersen y Mugrage [13]	Van Slyke-Neil	45	20 — 45	14.45
Osgood [11]	Osgood-Haskins	152	14 — 30	13.91
Wintrobe [12]	Newcomer	50	17 — 30	13.76
Sachs y col. [14]	Ferrimetría	10	20 — 28	13.50
Sachs y col. [15]	Ferrimetría	29	14 — 18	13.61
Ohlson y col. [16]	Duboscq	4550	16 — 30	13.40
Leichsenring y col. [17]	Newcomer	258	12 — 19	12.21
Belk y col. [18]	Haden-Hausser	25	——	13.47
Mirone, L. [19]	Oxihemoglob.	396	——	13.99
Promedio				13.59

que estas escolares estuvieron sometidas a una dieta deficiente tanto en cantidad como en calidad. Además, en este mismo grupo hubo un porcentaje elevado de infecciones tales como amigdalitis, leucorrea y caries dentales, las cuales podrían condicionar una menor utilización o un mayor requerimiento de los elementos formadores de sangre.

La cantidad de hemoglobina no fué influenciada, en forma aparente, por la procedencia de los sujetos en estudio, tampoco encontramos ninguna relación entre el nivel de hemoglobina y determinadas características menstruales tales como: cantidad, duración, regularidad, o irregularidad de presentación, ausencia o presencia de dismenorrea, etc., concordando así con lo encontrado por Leichsenring y col. (17). En cambio hemos encontrado una relación inversa, estadísticamente significante, entre el nivel de hemoglobina y el tiempo transcurrido entre la implantación de la regla y la toma de las muestras de sangre. El coeficiente de correlación (r) entre estas variables fue -0.4331 ± 0.1211. La hemoglobina disminuyó en forma lenta, pero definida hasta los 6 años de implantada la regla, llegando esta baja a alcanzar 1.23 gramos por 100 cc a los 6 años, después de lo cual se notó un ligero aumento a los 7 años y una estabilización en los años subsiguientes. Una relación en este mismo sentido y del mismo valor estadístico encontramos entre el nivel de hemoglobina y la edad de las mujeres estudiadas, siendo el coeficiente de correlación (r) igual a -0.3312 ± 0.0865. Estas dos últimas observaciones están de acuerdo con lo que encontraron Leichsenring y col. (17).

La Fig. 2 representa comparativamente las variaciones de las cifras de hemoglobina en hombres y en mujeres residentes en Lima. En ella podemos darnos cuenta que la cantidad de hemoglobina es mucho más alta en hombres, confirmando así lo que corrientemente se afirma de que

el sexo juega un papel importante sobre la cantidad de hemoglobina circulante.

Hematocrito. — En la Fig. 3 representamos la distribución de las cifras de hematocrito encontradas en 150 mujeres. La cifra media fué 41.5 ± 0.18 con valores extremos entre 35.9 y 46.5 por ciento. Revisan-

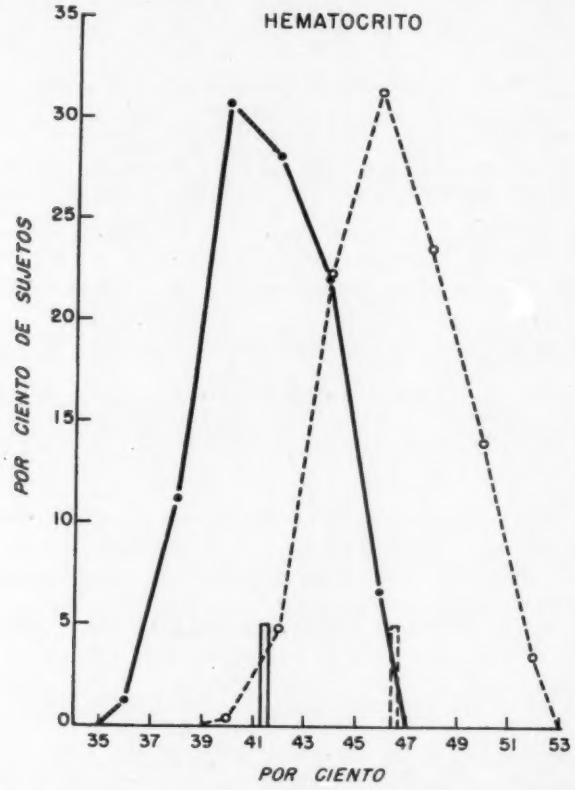

FIG. 3. — *Variación del hematocrito (hematíes por ciento) en 150 mujeres adultas (línea continua), en comparación con igual observación en hombres adultos (línea interrumpida) (20). Ambas investigaciones fueron llevadas a cabo en Lima.*

do la literatura europea y norteamericana, Osgood (11) encontró un promedio de 41.8 y Wintrobe (12) en una búsqueda similar encontró un promedio de 41.1 por ciento. En la tabla IV resumimos los resultados que encontramos revisando la literatura a nuestro alcance.

Como se puede apreciar, nuestros hallazgos son semejantes a los encontrados por Osgood (11) y a los promedios encontrados tanto por Osgood (11) como por Wintrobe (12) revisando la literatura mundial. Son

superiores a los dados por Wintrobe (12), Ohlson y col. (16) y Belk y col. (18), e inferiores a los encontrados por Andersen y Mugrage (13), aunque hay que hacer presente que estos últimos hicieron sus determinaciones a una altura de 1 524 metros sobre el nivel del mar.

La Fig. 3 representa la distribución comparativa de las cifras de hematocrito en hombres y mujeres residentes en Lima. Ella es una demostración gráfica del papel que juega el sexo sobre el hematocrito, ya

TABLA IV

Cifras de hematocrito encontradas en mujeres adultas sanas por otros investigadores

Autor	N° de casos	Edad	Hematocrito (por ciento)
Andersen y Mugrage (13) ..	45	20 — 45	43.2
Osgood (11)	152	14 — 30	41.0
Wintrobe (12)	50	17 — 30	39.5
Ohlson y col. (16)	4550	16 — 30	40.0
Belk y col. (18)	25	——	40.4
Promedio			40.8

que se puede notar que el volumen de eritrocitos es definitivamente menor en mujeres que en hombres.

Reticulocitos. — En la tabla I resumimos los resultados obtenidos en la determinación del número de reticulocitos en 120 mujeres. La cifra media fué 0.4 ± 0.36 con variaciones entre cero y 2 por ciento. En 53 casos no encontramos reticulocitos en el recuento rutinario de 1 000 hematíes.

Nuestros resultados son inferiores a los de Leichsenring y col. (17) y de Osgood (11), quienes encontraron un promedio de 1.08 y 1.5 por ciento respectivamente, pero concuerdan con las cifras dadas por Hurtado y col. (1, 20) para hombres normales de nuestro medio.

Indice ictérico. — En la tabla V resumimos los resultados obtenidos en 115 mujeres sanas. Nuestra media de 6.4 ± 1.20, con variaciones entre 3 y 12 unidades bicromato concuerdan con las encontradas por Hurtado y col. (1) en hombres normales de nuestro medio.

Volumen medio corpuscular. — En la Fig. 4 representamos la distribución individual de las cifras del volumen medio corpuscular que encontramos en 150 mujeres. La cifra media fué 94.1 ± 0.50 con variaciones entre 76.4 y 109.3 micras cúbicas. El 78.6 % de nuestros casos tuvieron un volumen medio corpuscular entre 80 y 100 micras cúbicas.

TABLA V

Indice ictérico encontrado en 115 mujeres sanas

	Mediat. ± E.S.	Desv. St. ± E. S.	Coef. Var. %	Valores extremos
Indice ictérico (Unidades bicrom.)	6.4 ± 1.20	1.29 ± 0.85	20.1	3.0 — 12.0

Este promedio es semejante al encontrado por Andersen y Mugrage (13), pero es superior a los encontrados por otros autores (11, 12, 16, 18).

Hurtado y col. (1) encontraron en 100 hombres sanos de nuestro medio, una cifra media de 89.7 ± 0.27, y posteriormente, en 175 casos,

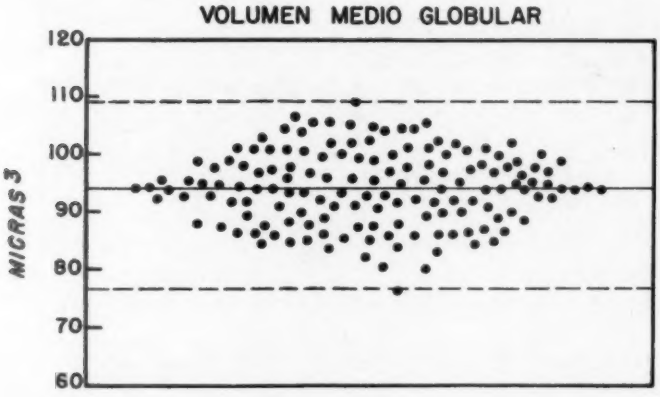

FIG. 4. — *Volumen medio globular (micros ³) en 150 mujeres adultas. La línea horizontal continua corresponde al valor medio.*

91.3 ± 0.23 micras cúbicas (20). El hecho de que nuestros resultados en mujeres sean superiores a las encontradas en hombres estaría de acuerdo con las observaciones de Andersen y Mugrage (13) de que el volumen medio corpuscular es significativamente mayor en mujeres que en hombres. A este respecto Wintrobe (21) dice que los hematíes en las mujeres son algo más grandes que en los hombres, alcanzando esta diferencia alrededor de 2 a 4 micras cúbicas en volumen.

Hemoglobina media corpuscular. — La Fig. 5 representa la distribución de las cifras individuales de los datos encontrados en 150 mujeres. El promedio fué 31.8 ± 0.20 con variaciones entre 27.1 y 37.9 micro-microgramos. El 79.3 % de nuestros casos tuvieron una hemoglobina media corpuscular entre 28.0 y 34.0 micro-microgramos. Nuestro pro-

medio es semejante al encontrado por Andersen y Mugrage (13), pero es superior a los encontrados por Osgood (11), Wintrobe (12), Ohlson y col. (16) y Belk y col. (18).

Concentración de la hemoglobina media corpuscular. — La Fig. 6 representa la distribución de los datos encontrados en 150 mujeres. La cifra media fué 33.8 ± 0.13 con variaciones entre 29.0 y 38.2 por ciento.

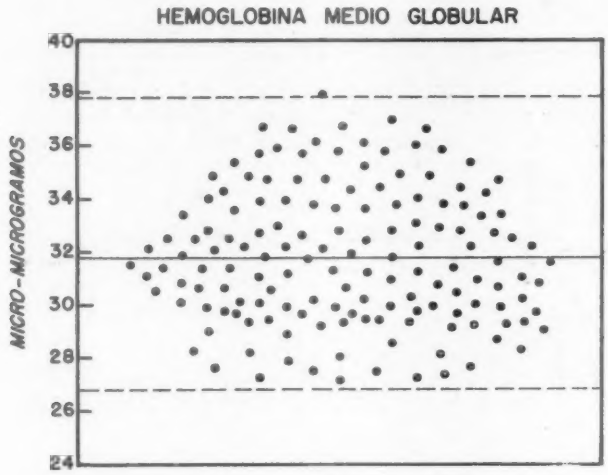

FIG. 5. — *Hemoglobina media globular (micro-microgramos) en 150 mujeres adultas. La línea horizontal continua corresponde al valor medio.*

El 75.3 % de nuestros casos tuvieron una concentración de la hemoglobina media corpuscular entre 30.0 y 35.0 por ciento. Nuestros resultados son semejantes a los encontrados por otros investigadores (11, 12, 13, 16, 18), y son también muy parecidos a los encontrados en hombres de nuestro medio por Hurtado y col. (1, 20).

Leucocitos. — La Fig. 7 representa la distribución de los datos encontrados en 150 mujeres, y la tabla VI es un resumen de los resultados obtenidos en estos estudios. Como se puede apreciar, obtuvimos una cifra media de 6 827 ± 147, con variaciones entre 3 300 y 13 250 leucocitos por mm^3. Osgood y col. (22) encontraron un promedio de 8 160 con variaciones entre 4 000 y 13 500 leucocitos por mm^3 en 46 niñas cuya edad era entre 15 y 18 años. Este mismo investigador (11), después de afirmar de que no hay diferencia sexual en lo que respecta a la fórmula diferencial leucocitaria, da un promedio de 7 400 con variaciones entre 4 500 y 11 500 leucocitos por mm^3 para adultos de ambos sexos cuyas edades variaron entre 19 y 30 años. Para niños de ambos sexos entre 8 y 18 años de edad, este mismo investigador (22) encontró un promedio de 8 342 con variaciones entre 4 500 y 13 500 leucocitos por mm^3. En 258 niñas entre 12 y 19 años de edad, Leichsenring y col. (17) encontra-

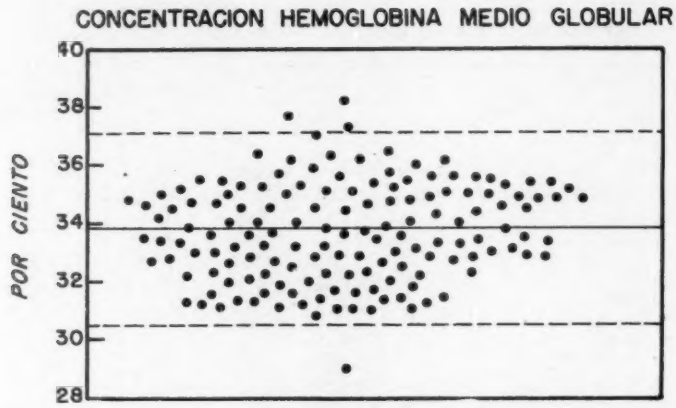

FIG. 6. — *Concentración media de hemoglobina globular (por ciento) en 150 mujeres adultas. La línea horizontal continua corresponde al valor medio*

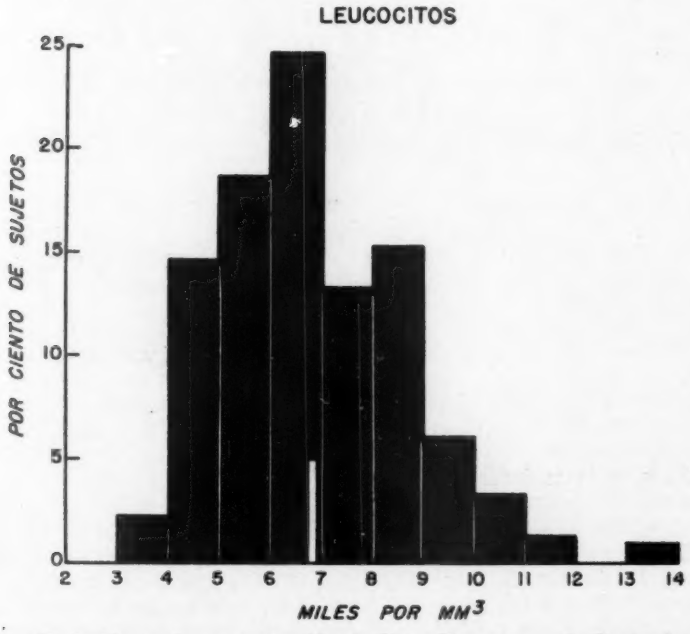

FIG. 7. — *Variación en la concentración de leucocitos por mm³ observada en 150 mujeres adultas.*

TABLA VI

Número de leucocitos y fórmula diferencial leucocitaria *

	Media ± E. S.	Desv. St. ± S. E.	Coef. Var. %	Variaciones extremas
Leucocitos ..... (por ciento)	6827 ± 147	1801 ± 104	26.4	3300 — 13250
Neutrófilos ..... (por ciento)	61.5 ± 1.36	9.64 ± 0.96	15.7	43.0 — 86.0
Abastonados ..... (por ciento)	5.7 ± 0.40	2.84 ± 0.28	49.8	0.0 — 12.0
Segmentados ..... (por ciento)	55.8 ± 1.29	9.11 ± 0.91	16.8	38.0 — 80.0
Eosinófilos ..... (por ciento)	3.6 ± 0.39	2.76 ± 0.28	76.7	0.0 — 14.0
Basófilos ..... (por ciento)	0.5 ± 0.09	0.67 ± 0.07	134.0	0.0 — 3.0
Monocitos ..... (por ciento)	5.8 ± 0.45	3.22 ± 0.32	55.0	0.0 — 16.0
Linfocitos ..... (por ciento)	30.3 ± 1.22	8.61 ± 0.86	28.4	12.0 — 52.0

* La cuenta de leucocitos se realizó en 150 mujeres y la fórmula diferencial leucocitaria representa el promedio de 50 casos.

ron una cifra media de 7 340 leucocitos por mm^3. Entre nosotros Hurtado y col. (1) en 85 hombres sanos encontraron un promedio de 7 060 leucocitos por mm^3 con variaciones entre 3 480 y 10 680, y en un trabajo posterior (20) nos dieron un promedio de 6 800 leucocitos con variaciones entre 3 480 y 14 840.

Fórmula diferencial leucocitaria. — La fórmula leucocitaria, determinada en 50 de nuestros casos, da valores en concordancia con los encontrados por Osgood (11, 22) en mujeres de Estados Unidos de Norteamérica, y por Hurtado y col. (1, 20) en hombres sanos de nuestro medio, presentando diferencia, únicamente, en el porcentaje de abastonados neutrófilos y de eosinófilos.

La cifra media de abastonados neutrófilos fué 5.7 ± 0.40 con variaciones entre cero y 12 por ciento. Como se puede apreciar en la Fig. 8, el 78 % de nuestros casos tuvieron una cifra de abastonados neutrófilos que fluctuó entre cero y 7 por ciento, variaciones muy parecidas a la encontrada por Osgood y col. (11, 22) en mujeres de los Estados Unidos, y muy semejante también a la que encontraron Hurtado y col. (1,20) en hombres adultos en nuestro medio. Hubo un caso en el que el nú-

mero de abastonados fué de 12, y tres en los que fué de 10 por ciento. Es posible que algunos focos infecciosos, no perceptibles al examen clínico, sean los responsables de estas cifras altas de abastonados neutrófilos.

La cifra media de eosinófilos fué 3.6 ± 0.39, con variaciones entre

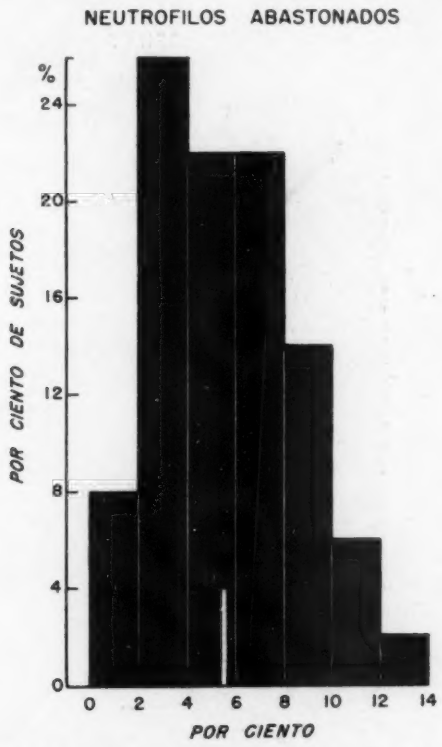

FIG. 8. — *Variación observada en el porcentaje de neutrófilos abastonados en 50 mujeres adultas.*

cero y 14 por ciento. En la Fig. 9 se puede apreciar la distribución de las cifras de eosinófilos en los sujetos estudiados. En ella se puede apreciar que el 82 % de nuestros casos presentaron una cifra de eosinófilos que fluctuó entre cero y 5 %. Osgood (11, 22) encontró una variación entre cero y 7 %, y estudios llevados a cabo en hombres adultos de nuestro medio, Hurtado y col. (1, 20), encontraron una variación entre cero y 5 %. Las cifras altas de eosinófilos que encontramos en los demás casos, posiblemente, se debe a parasitismo intestinal, lo cual no se puede descartar por no haber realizado exámenes coprológicos.

Volumen sanguíneo. — Los resultados obtenidos están resumidos en la tabla VII.

Nuestro promedio de 64.3 centímetros cúbicos de sangre circulante por kg de peso es muy semejante a la cifra de 64.4 centímetros cúbicos con variaciones entre 49.6 y 77.5 centímetros cúbicos encontrados por Berlin y col. (23) en 16 mujeres de California y cuyas edades fluctuaron entre 22 y 48 años.

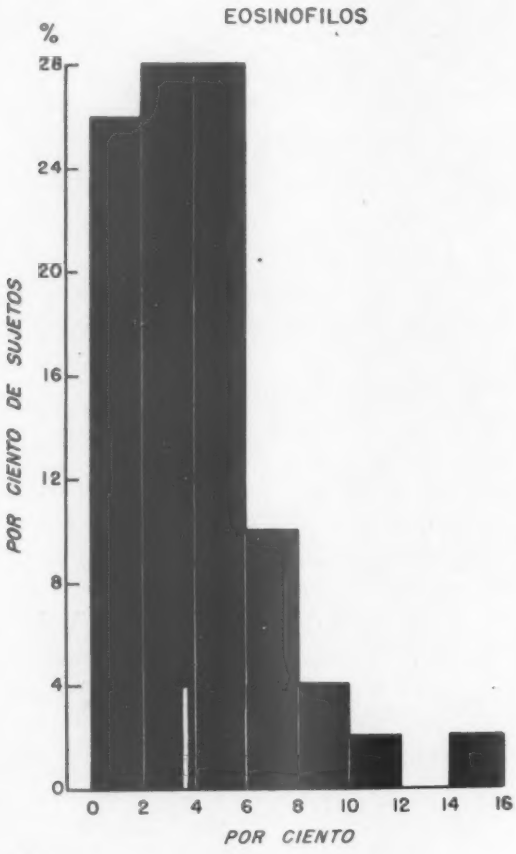

FIG. 9. — *Variación observada en el porcentaje de eosinófilos en 50 mujeres adultas.*

La cantidad de hematíes por kg. de peso fué ligeramente menor, y el plasma ligeramente mayor al encontrado en California. La diferencia fué de 1.5 y 1.8 centímetros cúbicos por kg de peso, respectivamente, aunque los valores extremos concuerdan con las fluctuaciones encontradas por nosotros. Berlin y col. (23) encontraron un promedio de 27 centímetros cúbicos de hematíes con variaciones entre 21.1 y 32.7 centí-

TABLA VII

Volumen sanguíneo determinado con P^{32} en 8 mujeres sanas

Caso número	Peso corporal (kg)	Vol. total de sangre (cc/kg)	Vol. total hematíes (cc/kg)	Volumen plasmático (cc/kg)	Hematocrito (por ciento)
1	60.4	66.7	25.3	41.4	38.0
2	71.3	67.5	26.6	40.9	39.4
3	48.0	56.5	22.0	34.5	38.9
4	51.8	59.9	22.8	37.2	38.0
5	60.8	76.5	30.2	46.3	39.5
6	54.4	55.1	21.5	33.6	39.0
7	48.0	66.1	26.6	39.5	40.2
8	56.0	66.2	29.2	36.9	44.2
Promedio ± E. S.		64.3 ± 2.46	25.5 ± 1.15	38.8 ± 1.46	39.6 ± 0.70
Desv. St. ± E. S.		6.49 ± 1.73	3.04 ± 0.81	3.87 ± 1.03	1.85 ± 0.49
Coef. Var. (%)		10.1	11.2	10.0	4.7
Variaciones extremas		55.1 76.5	21.5 30.2	33.6 46.3	38.0 44.2

metros cúbicos por kg de peso, y 37.0 centímetros cúbicos de plasma con variaciones entre 27.3 y 46.6 centímetros cúbicos por kg de peso.

El mayor volumen de hematíes circulante, en la mujer americana, posiblemente podría ser explicado por el mejor estado físico y nutritivo de ésta en comparación con la peruana.

En 1950, Lawrence y col. (24) usando P^{32}, encontraron en 14 estudiantes peruanos de medicina (hombres), un volumen sanguíneo de 71 centímetros cúbicos por kg de peso. De esta cantidad 32 centímetros cúbicos correspondieron a los hematíes y 39 centímetros cúbicos al plasma. La edad de estos sujetos fluctuó entre 21 y 27 años. Como se puede apreciar, las cifras del volumen sanguíneo total y del volumen total de hematíes en hombres son superiores a lo que encontramos en mujeres, siendo los volúmenes plasmáticos muy semejantes, lo cual está de acuerdo con lo señalado por Berlin y col. (23). Estos autores, tratando de explicar el menor volumen total de hematíes en mujeres, lo atribuyen al hecho de que el índice usado es centímetros cúbicos por kg de peso, y que es posible que si fuera calculado sobre la base del peso corporal libre de grasa, el volumen total de hematíes de las mujeres estaría de acuerdo con lo que se encuentra en hombres, ya que las primeras con-

tienen un mayor porcentaje de tejido adiposo, el cual es más pobre en agua que los otros tejidos.

Revisando la literatura no hemos encontrado estudios del volumen sanguíneo en mujeres realizados con P^{32}, además de los ya citados. Algunos investigadores han hecho determinaciones en pequeño número de mujeres y sus resultados finales lo han involucrado en estudios llevados a cabo en hombres. Así por ejemplo Wasserman y col. (25) en 39 determinaciones sólo tienen 3 casos de mujeres, y estos tres casos hacen un promedio de 59.5, 22.6 y 37.0 centímetros cúbicos de volumen sanguíneo total, volumen de hematíes y volumen plasmático por kg de peso, respectivamente.

Por otra parte, nuestros resultados no podemos compararlos con los obtenidos con colorantes, ya que la mayoría de los investigadores están de acuerdo de que el volumen sanguíneo determinado con la técnica del colorante es mayor que el que se obtiene ya sea con la dilución de hematíes marcados con P^{32} (25, 26), hierro radioactivo (27, 28, 29), o con el método de la dilución de la proteína plasmática (29). Debemos hacer presente que estos autores hicieron sus determinaciones simultáneas con azul de Evans. Wasserman y col. (25) creen que es posible que este mayor volumen encontrado con la técnica del colorante sea debido a la desaparición de éste del torrente circulatorio, inmediatamente después de hecha la inyección, ya sea por fagocitosis, adherencia del colorante a la pared de los vasos sanguíneos, o difusión dentro de los tejidos. Además, debemos hacer presente que al emplear el P^{32} o el colorante, estamos midiendo fracciones diferentes de la sangre, puesto que usando el colorante se determina el volumen plasmático y el volumen sanguíneo se mide en forma indirecta por medio del uso del hematocrito. En cambio, mediante el uso de eritrocitos marcados con P^{32}, el volumen sanguíneo se determina en forma directa.

Comentarios

El cuadro hemático de un individuo es el resultado de un equilibrio entre la formación y destrucción sanguíneas. Cuando uno de estos factores impera sobre el otro da por resultado estados de policitemia o de anemia. Además de este mecanismo de balance, existen otros factores que determinan el nivel normal de los constituyentes de la sangre. Entre estos factores es indiscutible el papel que juega el sexo sobre el volumen sanguíneo, cantidad de hemoglobina por 100 centímetros cúbicos y de eritrocitos por milímetro cúbico, no siendo afectados por este factor, en lo absoluto, la cifra de leucocitos ni la fórmula diferencial leucocitaria.

Nuestros resultados obtenidos en 150 mujeres sanas, comparados con los encontrados por otros investigadores (11 al 19) (22, 23), nos indican que factores como raza, clima y latitud geográfica, no juegan papel importante sobre el nivel de estos valores. Es posible también que los hábitos dietéticos no influyan en el nivel de los elementos sanguínos, siempre que el sujeto esté recibiendo una dieta bien balanceada, esto es, que la dieta no sea deficiente en los elementos necesarios para la formación

sanguínea, o que no haya un mayor requerimiento de estas substancias y que la absorción y aprovechamiento sean normales. Es indudable que en la mujer, durante la época sexual, las reglas determinen un mayor requerimiento de hierro, pero estas necesidades son llenadas con creces con una dieta bien balanceada en mujeres que no tengan procesos que interfieran en la absorción y utilización de este mineral.

El estudio estadístico de nuestros datos nos demuestran que los caracteres de la regla, dentro de ciertos límites, no juegan un papel importante sobre las constantes hematológicas, hecho que está de acuerdo con los estudios llevados a cabo por Leichsenring y col. (17).

En la literatura, a nuestro alcance, no hemos encontrado estudios de volumen sanguíneo realizados en mujeres con P^{32}. El único trabajo realizado por Berlin y col. (23) con P^{32}, en mujeres de California, da resultados muy semejantes a los nuestros.

Un factor muy importante en la determinación del volumen sanguíneo es el método que se emplea para medirlo, y es un hecho universalmente aceptado que las técnicas que lo miden indirectamente, como por ejemplo el azul de Evans, dan una cifra mucho mayor que las que lo miden en forma directa, como en la técnica usada en este trabajo.

Sumario

Se han llevado a cabo determinaciones hematológicas en 150 mujeres, aparentemente sanas, y los resultados obtenidos han sido sometidos a un estudio estadístico y comparados con estudios similares que se han realizado en otras partes del mundo.

Summary

This article concerns the investigation of some of the morphological characteristics of the circulating blood in 150 *healthy adult females. The study has been carried out in Lima (altitude*: 150 *meters; average barometric pressure*: 750 *mm Hg) and the results have been compared with similar observations made in other parts of the world in healthy women and men. The studies include eight determinations of blood volume using the radioactive isotope* P^{32}.

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Los trabajos deberán ser escritos a máquina en papel tamaño carta, no transparente, a doble espacio y con amplio margen. Las ilustraciones deberán estar numeradas (fig. 1, fig. 2, etc.), y llevar al pie una leyenda clara y concisa. Las fotografías hechas en papel brillante, nítidas. Los gráficos y diagramas, dibujados con tinta china sobre fondo blanco, listos para reproducir.

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Las citas bibliográficas se harán en el texto mediante números [por ej.: algunos autores ([2], [15]) y en especial Jones ([5])] o autores y año [por ej.: (Breslauer, 1919)]. Al final del trabajo la bibliografía se ordenará alfabéticamente y con numeración progresiva, en el primer supuesto, y alfabéticamente en el segundo. Para las abreviaturas de las revistas, etc., se seguirán las recomendaciones del World List of Scientific Periodicals. La disposición de tales citas debe ajustarse a los ejemplos siguientes:

([1]) Breslauer, J. D.: *J. Physiol.*, 1949, *151*, 50.

([2]) Goldberger, E.: *Unipolar lead electrocardiography*, Philadelpia, Lea and Febiger, 1947.

([3]) Gómez, S. L., Pérez, J. M., López N. A.: *Acta physiol. Lat.-Amer.*, 1950, *1*, 43.

([4]) Paege, L. M., Schlenk, F.: *Federation Proc.*, 1950, *9*, 212.

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Se exponen a continuación algunas abreviaturas comunes:

metro	m	litro	l	microgramo	µg
centímetro	cm	centímetro cúbico	cm^3	gama	γ
milímetro	mm	mililitro	ml	por ciento	%
micrón	µ	kilogramo	kg	hora	h
milimicrón	mµ	gramo	g	minuto	m
Ångström	Å	miligramo	mg	segundo	s
				milisegundo	ms

Para evitar la confusión derivada de la notación decimal diferente según los países, se adopta el punto decimal y se suprime toda notación entre millares sustituyéndose por un espacio: 10 000 (no 10.000 ni 10,000) —0.90 (no 0,90).

SUMARIO

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